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China's Search For Indigenous Industrial Development: A Case Study of the Aviation Industry

PhD Thesis

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Supervisor: Professor Ron Matthews

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ABSTRACT

The one common feature amongst all underdeveloped nations is their intent to develop. The question is how to achieve this goal in the most efficient and effective manner. China's recent premier, Deng Xiaoping, captured this challenge in what has become a celebrated metaphor …"It does not matter whether the cat is black or white; as long as it catches the mouse, it is a good cat." For China, the choice of development strategy has not been Communism or Capitalism, but rather a mixture of both with central direction and decentralized profit incentives combined. This unique model was launched at the time of the 1978 'Open-Door' policy and heralded a period of unparalleled growth and development. Access to technology to support the creation of modern industries came through foreign investment, and China's central planners were in a strong position to direct inward technology transfer to what were held to be the 'back-bone' industries essential for high technology industrialization.

The purpose of this dissertation, then, is to analyse China's development process, with particular reference to the development of the high technology aviation industry. Aviation (commercial aircraft production) is part of the broader industrial sector, aerospace. This represents one of the highest technology sectors, embracing knowledge-intensive activity, innovation, high skills and high value-added. Aviation is regarded as a strategic industry, and as such, China has viewed foreign technology not only from a development perspective, but also as a vehicle for achieving sovereignty and sustainability. In other words, China's long-term aim has been to develop an 'indigenous' aviation industry. However, such aviation ambitions are shared by several other Asian nations, including Japan, Singapore, South Korea, Malaysia and Indonesia. This thus makes the task of gaining technology from the major aviation giants, such as Boeing and Airbus, very competitive. Moreover, the drive to build commercial aircraft has both an economic and a nationalistic dimension, and so 'success' carries not profit but political rewards, also.

In evaluating the challenge Asia faces in developing an indigenous aviation industry, secondary and primary data were gathered, providing a sense of country strategy and performance. Japan is the technology leader, with countries playing the role of technology followers. China, however, is at the back of the pack, with limited local capacity and constrained indigenous capability. However, notwithstanding the country's 'chaotic' industrial development history over the last 50 years, the present powerful combination of high economic growth, massive demand for commercial air travel - and thus airliners, unlimited central government resources, command planning and an absolute commitment to succeed, suggests that China is strongly positioned to replace Japan as the aviation technology leader in the years to come.

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MAP OF ASIA

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Chapter 1 China's Industrial and Technological Revolution

1.1 Making the Case for the Study

This opening section of chapter one seeks to make the case for a high-level study of the development of China's aviation industry. Subsequent sections will outline the purpose, value, study pattern, and data-access strategy. However, at this initial stage, there is a need to sketch the study's contextual backdrop. Issues that need to be addressed include, why study China? Why industrial and technological development? Why aviation production? Necessarily, the starting point for such a discussion has to be China itself. Never before has the world witnessed an economic transformation that comes close to that presently taking place in China. The scale of the economic forces at work in China and their impact on the global economy is nothing short of a revolution.

1.2 China: The Great Leap Upwards?

Three centuries ago China's industriousness led the world. The Chinese had a history of creativity, inventing paper, gunpowder, printing, the compass and other advanced technologies. However, war, colonial subjugation and imperial suppression then constrained this creativity, and with it, the conditions for economic advance. Circumstances changed once again during the closing decades of the 20th century when liberalisation rekindled China's economic vibrancy. This current economic transformation is without doubt the greatest industrial revolution the world has ever seen. From nowhere, China's economy has grown dramatically, now accounting for 9 per cent of 'global' gross domestic product (GDP).[1] In dollar terms its GDP is the fourth biggest in the world, only slightly smaller than that of Germany;[2] and after adjusting for price differences, China's economy is second only to that of the United States (US).[3]

China's increasing economic strength is inevitably affecting world-trading patterns. It is now the second largest global exporter; total value of exports was 1.218 trillion U.S. dollars, up 27 percent year on year.[4] Trade with the US amounted to well over 60 per cent of this figure, making China the largest exporter of goods to the US.[5] China's growth surge is also affecting the import-side of the international trade equation. China will soon become the world's second largest importer after the US, by overtaking Germany.[6] This import growth has helped regenerate Japan's stuttering economy, and, more generally, has acted as a locomotive for Pan-Asian growth. There are many factors that account for China's remarkable boom, but two stand out as arguably the most influential, namely, politico-economic liberalisation and the role of foreign direct investment.

1.2.1 'Non-dependent' Politico-Economic Policies

For more than 2000 years the market mechanism in China was little developed. Partially, as a consequence of the absence of competition and trade, the idea of self-sufficiency became deeply rooted. Chinese people believed that they could achieve anything they wished without access to foreign capital and resources. This view of 'non-dependence' became even more entrenched following the creation of Communist China in 1949.[7] International isolation and strategic considerations played a crucial role in perpetuating China's emphasis on self-reliance. This was highlighted when the Korean conflict erupted in the early 1950s and China, as an ally of North Korea, faced an economic embargo from Western countries. As a matter of necessity, then, the early years of Communism were marked by a national effort to achieve economic reconstruction and industrial development. It reflected the Chinese view that there was little alternative but to develop self-reliance. Communist ideology strengthened still further China's parochial view of development. This was shown powerfully during the turbulent period of China's Cultural Revolution, and the manner in which the use of foreign (Western) capital was regarded as contradictory to socialism. Dependence upon capitalist countries was interpreted as 'losing face', whilst the contrary goal of 'creating face' could only be achieved through reliance on national endeavour.[8] This ideological approach dominated China's policy-making until 1976 when the Cultural Revolution disappeared under the weight of its own contradictions.

In reality, of course, self-sufficiency was always an ambitious goal, becoming near impossible today, particularly with regard to technological development. As a consequence, China collaborated with the Soviet Union, and from the 1950s onwards, numerous joint ventures were set up with the USSR and other countries from the socialist camp. Although investment values were small, China used rouble loans for obtaining complete (turnkey) plants. Examples of early projects included the Sino-Soviet Zhong Chang Railway, the Sino-Soviet Xinjiang Non-Ferrous Metal Company, the Dalian Sino-Soviet Shipbuilding and Repair Company and the Czechoslovakian International Marine Transportation Stock Company.[9] This post-Independence Chinese politico-economic model created paradoxes which continue to this day. For example, self-sufficiency remains a central part of China’s development policy, yet since the late 1970s it has been pursued alongside an agenda of openness, liberalisation and globalisation.[10] The country, moreover, remains wedded to Communist ideology, but the capitalist profit-motive has been the driving force, securing rapid economic growth. What has resulted is Communism and Capitalism co-existing together. This unique hybrid is termed ‘market-socialism’ (or capitalism with Chinese characteristics- *Shichang Shehui Zhuyi* 市场社会主义). However, not withstanding various ‘stresses and strains’, it is a model that appears to be working. Despite China’s huge swathe of moribund state-owned enterprises, protected by the highly interventionist policies of the central planning regime, market-socialism has provided the economic conditions for explosive growth. China's National Bureau of Statistics in January 2009 revised the country's 2007 gross domestic product (GDP) figure, which meant that China then overtook Germany as the world's third largest economy. China's GDP reached 30.07 trillion RMB (4.4 trillion U.S. dollars) in 2008, up 9 percent from a year earlier.[11] The GDP per capita was RMB22,640.81 (US$3312.92).[12]

1.2.2 FDI: Catalyst for China’s Rapid Industrialisation?

A key factor underpinning China’s economic success is Foreign Direct Investment (FDI). In 1990, China received $5.5 billion in foreign investment.[13] By 2007, this figure had grown to US$67.3 billion, making China the biggest FDI recipient amongst the developing economies.[14] Research suggests that foreign capital offers benefits to the recipient economy through exposure to modern manufacturing methods, leading to increases in capital intensity and labour productivity. The infusion of foreign capital acts as a catalyst for industrialisation. China’s policy makers, however, remain aware that FDI has its disadvantages. The downside of FDI was originally highlighted in what was termed, *dependencia* theory.[15] This theory argues that foreign enterprise exploits the host economy's markets, promoting little in the way of skilled labour, subcontractor links or added-value.

In China, both the central planning apparatus and foreign companies have seemingly gauged the net effect of FDI and reached the conclusion that the benefits outweigh the costs. Thus, as reported by the United Nations Conference on Technology and Development, more than 80 per cent of the Fortune 500 companies have invested in over 2000 FDI projects in China.[16] Moreover, because the government's policies seek to promote future investment, FDI growth is expected to continue, with economists predicting that during the next Five Year Plan (2006-2010) FDI values will reach $100 billion a year.[17]

China's FDI policy has its origins in the nineteenth century. In 1899, the US proposed to Imperial China that it should adopt an open door policy (*Menhu Kaifang* 门户开放).[18] This initiative was designed to coax the country into exposing its market to overseas business, but history has shown that *Menhu Kaifang* was a false start. For 50 years, up to the advent of Communism in 1949, FDI had only a limited impact. There were some pockets of foreign investment: in the 1930s fledgling aircraft industry, for instance, but the investment was of only marginal importance and constrained to Shanghai and the north.[19]

Between 1949 and 1978, FDI opportunities became even more limited. Apart from China's ill-fated 1950's industrial co-operation with the former USSR, the Beijing government effectively closed its door to multinational business. Soviet collaboration ended in the late 1960s and China again became technologically isolated. Obsolete equipment and techniques that had been imported in the 1950s still constituted the 'backbone' of industrial capacity a quarter of a century later. As a consequence, China's technological frailties were revealed and reform became urgent. The reforms finally came in the late 1970s and the turning point was the 1978 Third Plenum of the Communist Party. At this conference, China committed itself to the four modernizations; that of agriculture, industry, science and technology, and national defence.[20] The purpose of modernisation policy was to quadruple China's 1980 GDP of RMB 480 billion to RMB 1800 billion by the year 2000.[21] The 'trickle-down' effects of this growth would be to raise the living standards of Chinese people through economic development.

To realise this ambitious quadrupling growth objective, China needed capital, technology and managerial expertise. The new Chinese leadership formulated the path-breaking policy of economic reform and the opening-up of the economy to the outside world. The architect of this policy was Deng Xiaoping, who sought to introduce a new 'open policy' (*Kaifeng Zhengce* 开放政策).[22] At the heart of this open policy was the need to attract FDI. There were several reasons why FDI was considered important:

- Foreign capital was viewed as essential for compensating the shortage of local capital, without increasing China's external debt burdens
- There was a requirement to simultaneously upgrade local technology, equipment and management skills
- Technology transfer would improve local production through its impact on economic structures and product quality, thereby encouraging export-oriented practises
- FDI would help towards the training of local technical and management personnel, promoting China's foreign economic co-operation
- Foreign capital would help to increase job creation and income generation.

Thus, economic modernisation was viewed as impossible in the absence of international co-operation. Second time around, policies were evolved to ensure that the 1979 open-door policy actually meant open-door. For instance, the Act of Joint Venture Enterprises, endorsed by the 1979 National People's Congress, ensured the legal rights of multinationals, giving them access to China, albeit through joint ventures with local Chinese firms.[23] Wholly foreign-owned enterprises were at last allowed to operate, but only in certain areas.[24] The post-1978 policies moved aggressively to open-up China to foreign capital and along with appropriate economic liberalisation policies, the aim was to make China's local market an attractive place for foreign companies to invest in production facilities and even research and development (R&D).

A further important policy development to encourage foreign investment into China was the country's 2001 membership of the World Trade Organisation (WTO). This led in the following year to foreign companies finally being able to buy 'controlling' positions in domestically listed Chinese firms.[25] This was a significant policy step, heralding China's embrace of globalisation, and since 2001, the country's commitment to the WTO's regime of economic liberalisation and deregulation has been substantial. For instance, in agriculture, across a transition period of five years, Beijing agreed to reduce tariffs from an average level of 31.5 per cent to 17.4 per cent.[26] For industrial products, it promised to quickly phase out quantitative restrictions, cutting the average tariff from 24.6 per cent to 9.4 per cent.[27]

China has also agreed to sign the WTO's information technology agreement, resulting in the elimination of tariffs on telecommunications equipment, aerospace and IT products, with the most far-reaching changes reserved for the local services sector. Restrictions hitherto facing foreign service providers in areas such as licensing, equity participation, geographical location, business scope and operations are to be relaxed over time. Significantly, Beijing has decided to open-up telecommunications, financial services, distribution and other service-related industries to FDI. Apart from improving market access, the Chinese government has also agreed to increase the transparency of its trade regime. It plans to end all prohibited subsidies, liberalise trading rights and require State trading companies to operate in a commercial manner.

Liberalisation has clearly hastened investment inflows. In the past two decades, China has attracted a cumulative $400 billion in FDI; the third biggest amount after the US and UK.[28] Yet this huge figure constitutes just four per cent of China's GDP, compared with 39 per cent for the UK.[29] Although China's FDI is small relative to the size of its economy, its impact has been amplified by investment focused on key sectors, as demonstrated in Table 1.1 below. In 2007, manufacturing accounted for more than 51 per cent of China's total contractual FDI value.[30]

Table 1.1: Distribution of FDI in China for 2007

Unit: 100million US$

Sector	No of Projects	Share %	Contractual FDI Value	Share %
Total	37882	100	835.21	100
Agriculture, Forestry, Animal Husbandry& Fishery	1048	2.77	9.24	1.11
Minging	234	0.62	4.89	0.59
Manufacturing	19193	50.65	408.65	48.93
Construction	308	0.81	4.34	0.52
Transport, Warehouing, Post& Telecommunications	658	1.74	20.07	2.40
Computer And Software	1392	3.67	14.85	1.78
Wholesale, Retaining	6338	16.73	26.77	3.20
Hotel And Restaurant	938	2.48	10.42	1.25
Finance	72	0.19	90.10	10.79
Real Estate	1444	3.81	170.69	20.46
Lease And Business Services	3539	9.34	40.19	4.81
Scientific Research, Technology Service and Geological Prospecting	1716	4.53	9.17	1.10
Management of Water Conservancy, Environment and Public Equipment	154	0.41	2.73	0.33
Residential Services and other Services	270	0.7	7.23	0.8
Education	15	0.04	0.32	0.04
Health Care, Social Security & Social Welfare	13	0.03	0.12	0.01
Culture, P.E. and Entertainment	207	0.55	4.51	0.54
Public Management and Social Organization	1	0		

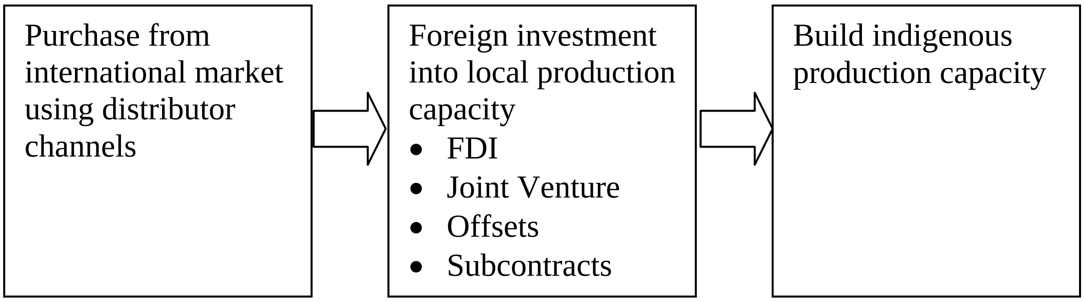
Source: Ministry of commerce of the People's Republic of China (www.fdi.gov.cn) 2009, http://www.fdi.gov.cn/pub/FDI/wztj/lntjsj/wstzsj/2007nzgwztj/t20081110_99059.htm

1.3 Strategic Industries: China's Technology Development Paradigm

The targeting of foreign investment into China's strategic sectors, or what the authorities call 'backbone' or strategic industries (terms used interchangeably in this study)' has not happened by accident. It has been a deliberate policy by both the foreign companies and the Chinese government; the former, because global growth is located in these high technology sectors, the latter, because of the interventionist nature of Beijing's policymaking. China's policy was based on Plan 863 (named after the date of its introduction: March 1986). The Plan aimed to promote what is now widely termed 'dual-use' industrialisation: the development of local capacity in sophisticated commercial technologies applicable to both the defence and commercial sectors.

FDI has been instrumental in the development of China's strategic industries; these, as a consequence, have become mainly foreign-owned and managed. As a result, such industries are integrated into the global technology value-chain, enabling China to accelerate its industrial and technological transformation, normally, a long process. Beijing's strategy seeks to avoid reinventing the technological wheel, rather it is aimed at exploiting advances made elsewhere, of trying to leapfrog the traditional early stages of industrial development. In this regard, fostering FDI as the vehicle for technology transfer is perceived as the most cost-effective way forward. Beijing's policy approach is therefore interventionist, emphasising liberalisation, competitiveness and globalisation. Multinational investment is attracted to China and targeted on designated high-tech sectors, including chemical fibres, precision machinery, biotechnology, energy development, aviation and space.[31] Beijing aims to evolve a dynamic comparative advantage in these technology sectors. Aviation production is recognised as a key enabler for industrial and technological development. China thus aims to facilitate the development of these technology-lead sectors, recognising that it needs to foster access to relevant dynamic technologies.[32] Figure 1.1 shows that the country has three options: purchase commercial aircraft on the open market; promote local production capacity through attracting MNC investment; and/or build indigenous production capability. China's development policy has been to proceed sequentially through each of these three stages. The thrust of this study is to evaluate its progress towards achieving indigenous production, the final and most difficult industrial and technological challenge (see analysis in Chapter 5).

Figure 1.1: China's Stage Model for Aviation Industry Development



Source: author

For the purpose of formulating this study's focused aim, these introductory comments have sought to make the case for an evaluation of the development performance and status of China's aviation industry. The planning authorities formally recognise aerospace as a strategic industry making a strong contribution to the industrialisation of China. The sophisticated technological nature of the industry's outputs will, moreover, lead to beneficial spin-offs, both horizontally and vertically, in the country's production processes. China's aviation industry, therefore, is politically, economically, and culturally, of huge intellectual and practical significance to observers from both the Orient and Occident alike.

1.4 Aim

The purpose of this study is two-fold: firstly, at a general level, to evaluate the development of Asia's commercial aviation industry, and, secondly, at a more focused case-study level, to offer an analysis of China's progress towards the policy goal of achieving indigenous aviation capacity.

1.4.1 Enabling Objectives

- Evaluation of the theoretical rationale for promoting economic development through Foreign investment

- Appraisal of post-Independence policy development in China aimed at developing local, diversified industrial capability through the creation of strategic industries
- Description and empirical analysis of the development of major Asian aviation industries, particularly progress sustained via indigenous industrialisation
- Description and empirical analysis of the development of one of China's more important strategic industries, the aviation industry
- Deep analysis of the 'effectiveness' of technology transfer, including both foreign investment and offsets, creating the skills and capability for self-sustainable growth in China's indigenous aviation industry

1.5 Study Value

China's economic model is one that is currently the focus of global attention; the reason is simple, it is successful. Stellar growth rates over the past quarter of a century have led to the transformation of China's economy. Throughout this period, Beijing has sought to upgrade, diversify and expand its industrial base. Although Chinese manufacturers have exploited their abundant low-cost labour to become globally dominant producers in such goods as toys, bicycles and textiles, the thrust of China's development strategy has been directed towards moving up the technological ladder. Policymakers have sought to 'evolve' a dynamic comparative advantage in higher value-added technology fields, such as aviation, telecommunication, automobiles, and microelectronics. These industries have been recognised as strategic growth poles within the Chinese economy, generating skilled workers, local research and development capacity, and also labyrinths of innovative local sub-contractors. The ultimate goal of this development process is to lay the foundation for indigenous industrialisation. If this can be achieved then these strategic industries will act as catalysts not only for industrialisation but also for accelerated transition from low to high value-added technological development. The strategic industries will radiate innovation and efficiency benefits, both upstream and downstream, across China's economy.

Aviation represents one of China's principal strategic industries. The aviation industrial development path, i.e. heavy reliance on technology transfer has been the typical approach followed by the planning authorities for the development of China's modern industrial sectors. Foreign MNCs have established manufacturing facilities in China, such that an emerging consolidated oligopolistic market structure has been created. Although a production base exists, the real issue is: how ‘deep’ has been the process of industrialisation? If the MNCs have only created assembly operations, generating minimum skills and value-added, then this is a ‘shallow’ form of industrialisation. Not only will there be few technology benefits transmitted to the broader manufacturing sector, but the lack of ‘deep’ industrialisation will perpetuate China’s dependence on overseas suppliers. This study’s originality, and hence ‘contribution to knowledge’, comes from its empirical evaluation of China’s performance in developing aviation manufacturing capability. Moreover, a cross-sectional analysis has been conducted, not only across sectoral cases in China’s aviation industry, but also across other country aviation industries in Asia. This is the first applied-empirical academic research project to investigate this focused subject.[33]

1.6 Conceptual Framework

The present study is concerned with the role and effectiveness of inward technology transfer in support of Chinese industrialisation. The starting point for discussion, however, goes back to the policy issue that all countries have to face: how best to effect economic development? There is no magical solution, no ‘one-size-fits-all’ industrialisation strategy that can be applied to all underdeveloped countries, under all circumstances. Actual technology development will depend on the success of broad-based development technology strategy/planning and the extent of technology access.

1.6.1 Asian Regional Context

Industrial strategies have to be designed and refined so that they are appropriate to particular economic conditions at a point in time and adapted as the dynamics of macroeconomic conditions change. Surprisingly, even in a 21st century context, characterised by rapid globalisation, the desired end-state for many developing countries is still what is variously termed self-reliance, self-sufficiency or indigenisation. Essentially, this is the point at which the local economy can claim to have created the capacity for both broad and deep industrialisation. This is clearly an ambitious policy goal, but one which, for instance, India, South Korea Japan and many other Asian Countries, including China, still seek to achieve.

Asian countries, such as Japan, South Korea, Singapore and Malaysia have all followed similar development paths as that of China. Their immediate aim has been to promote industrialisation, reducing dependence on agricultural cash crops. Yet, whilst strategies may differ between states regarding, for instance, the nature of government interventionism, the ultimate goal is the same: to industrialise, promote technological capability and achieve economic sovereignty through indigenous production. Whether the countries enjoy rapid or conservative economic growth, at some stage, policies will need to be formulated to promote science and technology and increase value-added. This will most likely arise from enhanced skills, the creation of local specialist supply chains and local research and development. None of this will be easy; there will be serious costs involved; it will take time to develop the skills and competences, and the industrial infrastructure will need to be evolved. Notwithstanding these barriers, Asia's search for local high technology capacity remains as strong as ever. This is no more than true than in aviation. It is matter of national security, defined as both economic and military, to develop domestic production in this important 'strategic' industry.

For the Asian countries, the typical strategy for developing production capacity is to 'piggyback' (*Dapei* 搭配) on progress achieved in the advanced countries. The results from such a strategy are mixed, with Japan at one end of the spectrum, having achieved remarkable success, and Indonesia, at the other, suffering stagnation and a diminution of capacity. As a latecomer to development, generally, and for aviation, in particular, the real question is how has China has progressed, both in relation to its own domestic economic context and when benchmarking against competitors in the Asian regional context.

Indigenous industrialisation is dominant in the thinking of China's leaders because, as hitherto stated, often in the country's history it has suffered colonial exploitation, suppression, and dependence on foreign supply. Consequently, it has become almost ingrained in Chinese culture that dependence on outside sources must be minimised.

Chinese government statements have affirmed, and continually re-affirmed, the overriding importance of this policy objective. Note, for example, the following technology-driven statement by Jiang Zemin in his mid-1990's speech to the Chinese people:

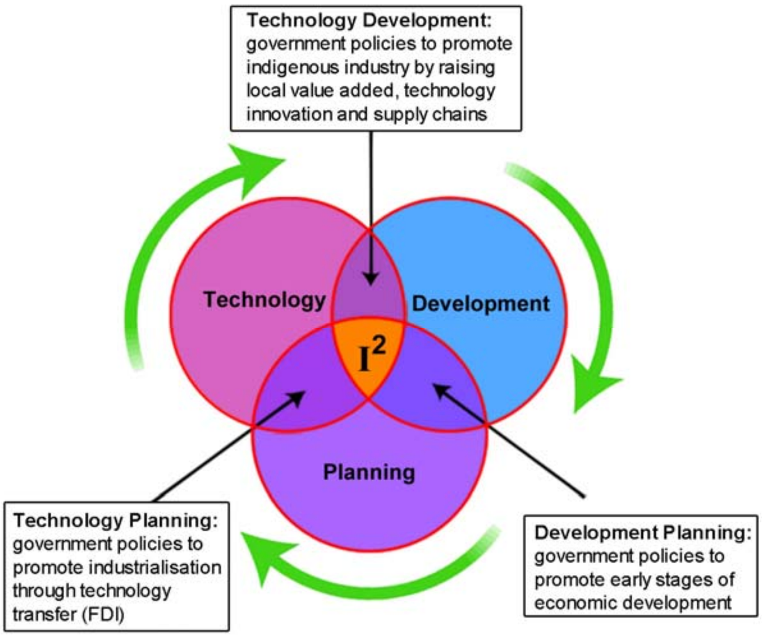
- "We must understand clearly that the world's most advanced technology is not for sale…New ideas are the very soul of national progress and are indispensable to the development of any country. If we do not have our own autonomous ability to create innovation and just depend on technology imports from abroad, we will always be a backward country… As a great socialist country, we must, in the field of science of technology be master of our own fate…As we continue to learn from others and to import advanced foreign technology, we must remain focused on raising China's ability to do research and development on its own…"[34]

In the design of an appropriate Chinese aviation development 'model' not only must the broad 'macro' policy aspects be captured, but also the more focused 'micro' structural and technology issues associated with the 'deepening' of local industrial development. The method adopted for this study is detailed in Figure 1.2 below (developed further in chapter 2). The venn diagram identifies the three principal attributes for effective indigenous industrialisation; that of, development planning, technology planning and technology development (the latter defined not just in terms of growth, but also the ability to secure high levels of sustainable competitive performance in a dynamic global business environment). Whilst there may be some overlapping, the industrialisation process is sequential, systematic and strategic, as explained in the following sub-sections.

1.6.2 Development Planning

The development planning interface in Figure 1.2 highlights the identification and selection of development plans appropriate for the fostering of local industrial and technological development. The vehicle for most countries' industrial planning is the Five-Year Development Plan. The Soviet Union, since 1928, and India, since 1951,

Figure 1.2: Modelling Indigenous Industrialisation (I^2)



Source: author

provide good examples of countries that have employed Five-Year Plans. China has trodden a similar path and since its First Five-Year Plan (1953-1957) introduced a succession of centrally coordinated development programmes. Their purpose is to identify, prioritise and coordinate development activities within investment constraints. The initial development of underdeveloped countries may involve costs if the development regime allows market forces full rein. These are the costs of competition, arising when firms compete in a fledgling industrial sector and, as a result, suffer high unit costs caused by over-competition and thus capacity underutilisation. Government has an interventionist role to play in guiding investment and resources in the framing of appropriate consumption-goods or capital-goods led development policies. This is particularly important in the development of balanced or unbalanced investment approaches and import-substitution or export-promotion strategies. Whatever the development policy, economic transformation will focus on industrial expansion and diversification. The initial development push, in turn, will necessitate the design and implementation of technology plans.

1.6.3 Technology Planning

The next stage in the progression toward indigenous industrialisation is technology planning. This is concerned with determining how best to source the technologies required to fuel the industrialisation push. Few latecomers to industrialisation aim to reinvent the wheel by undertaking the high cost R&D option to create new technologies. By definition, under-developed economies are resource-constrained, lacking the physical and human capital for frontier invention-innovation product and process development. Industrial latecomers, therefore, will benefit from following the technology 'leader', a dynamic advanced country driving technological advance. Latecomers can thus emulate 'best-practise' management and organisational approaches and 'share' the fruits of technological progress achieved elsewhere.

In the globalised environment that now characterises the international economic and financial system, the normal conduit for transferring technology from one country to another is FDI. Additionally, in the contemporary era, a further vehicle for technical transfer is what is called 'offsets'. This occurs because of the tight international sellers' market for high value items, such as aircraft. In such circumstances, purchasing countries demand offsetting investment, normally the means for locally producing the constituent components and/or subassemblies of the aircraft being purchased. This is not necessarily a 'win-win' process, however, as the transferring MNC will be intent on ensuring that its valuable 'brand' and cumulative R&D investments will be safeguarded. By contrast, the local company will be endeavouring to exploit extant learning and capabilities developed elsewhere. Dependent on the recipient's technological absorptive capacity, technology transfer will either be a positive or neutral learning experience for the transferee. Academic studies have indicated, for instance, that India's early in-country foreign collaboration machine tool ventures proved neutral, with minimal 'deepening' of local capability occurring.[35] Whilst the capacity to produce a broad array of machine tool models was achieved, India's manufacturers were unable to reduce dependence on foreign partners for the next generation of technology.[36] In other words, Indian firms were able to 'productionise but not indigenise'. Japan, on the other hand, was better placed to effectively absorb the technologies transferred by its overseas collaborators.[37] Japan, during most of the 19th and 20th centuries employed huge numbers of highly trained cadres of scientists and engineers dedicated to the process of 'reverse engineering'. These skilled workers were also focused on the development of 2nd and 3rd generation technology, representing improved versions of the original overseas design. Thus, since the late 1860s, Japan has been playing technological 'catch-up' with Western countries, a process that in some of Japan's high technology sectors, continues today.[38]

China's contemporary technology planning regime closely emulates Japan's policy experience. The Chinese government has for the past 50 years been introducing science and technology, trade, and industrial policies to encourage local industrial development through technology transfer. The principal medium for this transfer has been FDI. Policies such as Deng Xiaoping's 1979 'open-door' model, WTO membership, and a whole cluster of other industrial plans have acted in concert to provide the appropriate conditions for attracting the enormous FDI values that have found their way into China over recent years.

1.6.4 Technological Development

The final key element highlighted in Figure 1.2 is technology development, reflecting actual industrialisation through the development of key sectors. Although an important part of the planning apparatus for developing countries, the targeting of development on important sectors of the local economy does not normally form part of the policy approach in the advanced countries. The already advanced economies are more likely to be subject to market forces, with less reliance placed on government interventionism.

However, whilst not formally based on an interventionist policy, FDI transfers into, say, the US or the UK, are in the main sourced from global high technology manufacturers; the latter's products being more appropriate to the refined market segmentation and higher income levels of consumers in the advanced economies. At the process level, MNC intermediate technology outputs are compatible with the production capabilities and skill-sets of Western industrial sectors. Adam Smith's view of this production process is that it is guided by an 'invisible hand', i.e. the market.[39] Smith argued that the market allocatory mechanism is driven by the constant search for profit. Local and

MNC investment therefore gravitates naturally to the growth poles within the economy to capture economic 'rent' (super-profit). Market conditions are, of course, less sophisticated and less open in the industrialising countries. Incomes are low, and a middle-class, whose demands are essential for the promotion of consumer durable goods production, has yet to emerge. Labour is plentiful, but normally low-skilled, and a manufacturing substructure of specialist suppliers is also absent. In such under-developed economies, it is the government's responsibility to manage industrialisation. This is normally done through the adoption of an interventionist approach; that is, an institutional 'visible-hand' to guide scarce resources to the 'strategic' sectors within the economy.[40] The notion of strategic industries will be examined in more detail in Chapter 5, but at this stage it is important to recognize that China's policymakers have followed this 'visible-hand' approach, with the aim being to promote a spectrum of designated high technology 'backbone' or strategic industries.

China's backbone industries are held to be of policy significance for three principal reasons:

- Firstly, they are seen as drivers for rapid industrialisation. These industries are expected to employ large numbers of workers (many of whom are highly skilled), they also contribute greatly towards the growth of output and export opportunities, hence earning valuable foreign exchange.
- Secondly, the strategic industries are viewed as catalysing agents in the promotion of local technological development. The industries are characterised as high technology, high value-added, and knowledge-intensive, specialising in productive activities such as telecommunications, avionics, machine tools, transportation equipment and microelectronics, including aviation.
- Thirdly, the strategic industries are, rightly, interpreted as 'dual-use' industries, and are therefore critical to the servicing of China's defence-industrial needs. Plan 863 symbolises this process of civil-military integration in that it emphasises policies designed to encourage the development of dual-use strategic industries for national security purposes.

1.6.5 Indigenous Industrialisation

For China, as with most other industrialising countries, the policy goal of government planning is indigenous industrialisation. To this end, there is a recognition that whilst inward technology transfer is necessary to foster industrial development in a cost-effective way, it is not sufficient. Also important is the need to 'localise' the technologies transferred. Strategic industries can thus play a critically important role in generating the sophisticated skills and technological expertise essential for pursuing technological development.

The confluence of the circles shown at Figure 1.2 illustrates that indigenous industrialisation (I^2) is the outcome of development planning, technology planning and technology development targeted on the establishment of strategic and other lead industries. As stated in the study aim, the purpose of this research and, indeed, its 'contribution to knowledge', is thus to offer an analysis of the development of one of China's most important strategic industries, that of aviation. The study focus is on the 'effectiveness' of technology transfer. In essence, is China making progress in achieving its policy goal of indigenous industrialisation or is the process one of dependent technological development? Indigenisation depends on China's capacity to 'absorb' the technologies transferred and this will be influenced by industry-level considerations such as government science and technology policy and cross-cultural assimilation, i.e., the likelihood that foreign and Chinese business cultures can fuse and create synergies. Technological absorptive capacity facilitates indigenisation. However, to measure progress towards the indigenisation goal requires performance criteria. This is explained in greater detail in section 2.6 (Figure 2.10) of chapter 2, but it is suffice to note at this point that this study will employ three metrics: the level of local value-added; the capacity for technological innovation; and the degree of sophistication of the local value chain.

1.7 Choosing an Appropriate Research Method

The choice of research method is an important element in doctoral study. Indeed, for some PhD theses, methodological design represents the original contribution to knowledge. This does not apply in the present study, but it is acknowledged that the process of data acquisition must be clearly explained and justified. Thus, in the discussion that follows, the factors influencing the choice of research methodology will be addressed. There are two main issues:

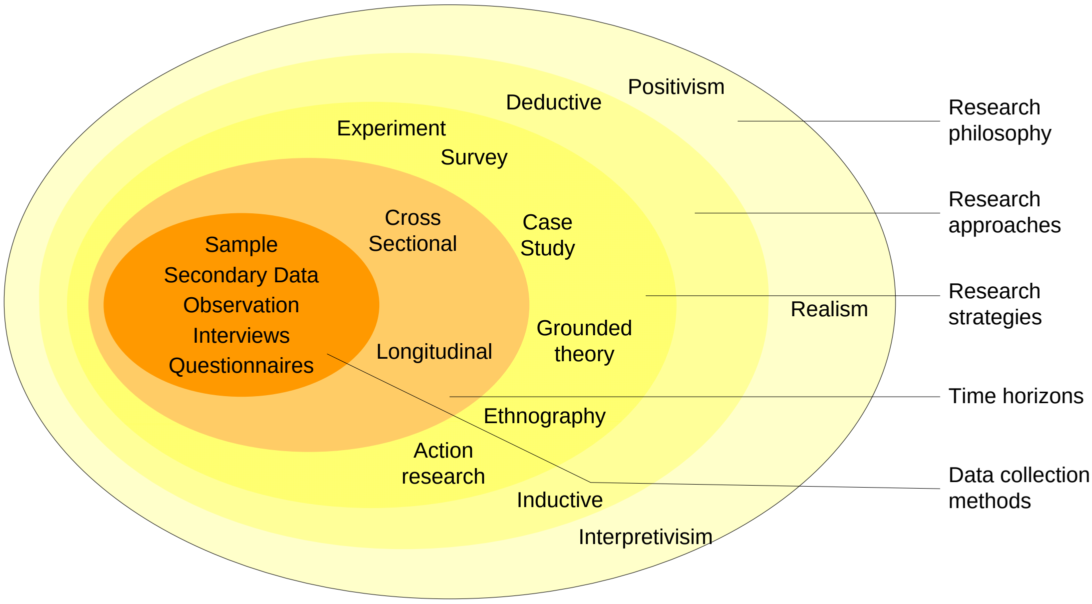
- Firstly, examining the purpose, philosophy and process of the research methodology options (sub-sections 1.7.1-5)
- Secondly, the application of such understanding to the development of an appropriate methodological framework for empirical evaluation of China's aviation industry (sub-section 1.7.6).

Saunders et al have summarised the range of research methods available to students, representing them graphically as the research 'onion'.[41] As the construction of this onion is complex, its constituent elements require explanation. Thus Figure 1.3 illustrates an adapted 'onion' structure, with the linked text seeking to explain its cell structure.

1.7.1 Research Philosophy

Research methodology is concerned with data acquisition. There are numerous philosophical schools of thought helping to shape decisions on the choice of appropriate methodology. These schools debate issues such as deductive v inductive theoretical reasoning and the use of qualitative v quantitative analysis. Collis and Hussey evaluate the latter debate by reference to two philosophical paradigms: the first is 'positivistic', including cross-sectional studies, longitudinal research and surveys; the second is 'interpretivist' concerned with case studies, ethnography, grounded theory and participative enquiry.[42] The principal difference between these two forms of research philosophy is that the positivistic tends towards the acquisition of numerical data, whilst the interpretivist emphasises the qualitative approach. There is, of course, a distinction between the two paradigms, but the reality is that the two schools are not mutually exclusive but mutually supportive. Acquisition of primary data and its associated qualitative interpretation go hand-in-hand.

Figure 1.3: Options within the 'Research Process'



Source: Adapted from Saunders, M. Lewis, P and Thornhill, A, 'Deciding on the Research Approach and Choosing a Strategy', in *Research Methods for Business Students*, Pearson Education, (2004), pp 84-112.

The scientific research approach typically adopted by the natural scientist or natural philosopher is most often associated with *positivism*. The principle for this approach is mainly concerned with observable phenomena that can be gathered impartially, subsequently analysed, and then repeated under controlled conditions if necessary. The strategy has objective characteristics where emphasis is placed on method, structure, repeatability and the application of quantitative techniques. There is often a tacit assumption that the observer does not affect the observed; that is, the researcher is able to stay detached from the study subject.[43] This last point must be seen as a goal; it is certainly subject to challenge, especially in the fields of the physical sciences, where it is often difficult or impossible to observe any phenomena without effect.

The positivist approach usually begins with the *deduction* of a hypothesis derived from available theory. A hypothesis is essentially a proposition made as a basis for reasoning or indeed as the starting point for further research from currently known facts. A hypothesis will make some statements about a relationship between entities, their behaviour as a function of such a relationship, dependencies, and so on. The hypothesis is then expressed in meaningful terms using descriptions accessible in the real world, in this way it is possible to devise real mechanisms for measuring and making observations. This process is known as reductionism, whereby a problem or hypothesis is broken down into smaller and simpler component parts so that they may be better understood. Subsequent measurements then become part of a test, perhaps in the form of an experiment or some other type of inquiry, and the outcome of the tests usually indicates the strength of the hypothesis in some way. The hypothesis, or indeed the experiments, may then be modified and repeated to improve correlation of the hypothesis to theory and, if successful, current theory may be modified in light of a successfully tested hypothesis.

It is important to recognise that the initial hypothesis is simply a groundless assumption, containing no presumption of truth and is a practical opposite to *theory,* which itself is a system of facts that already reliably explains something. This may sound rather counter-intuitive but the whole point of this type of research strategy is ultimately to test rigorously the statements contained within a hypothesis for significance. The gathering of data and the relationships between variables is the root of deduction and is embodied in many standard statistical techniques, such as the Student T test, which is specifically designed to test the similarity (or differences) between hypotheses. This is basically an *a priori* method, where truth can be deduced before experience and observation.

The other high level research philosophy is termed interpretivism. This has regard to research undertaken in a humanistic environment, less appropriate to scientific analysis that is subject to the hard laws existing in the physical sciences. The social science context of business and technology management is more complex, and if the complexities are not acknowledged and investigated their influence on behavioural factors will be lost. Cultural and environmental ‘invisible’ considerations are powerful and generalisable qualities that affect visible outcomes. Thus, an interpretivist researcher seeks to discover the cause(s) behind the reality. This is often described as social constructivism. In this sense, reality is viewed as the result of a social construction of events; of people’s social interactions; of motives, intentions and social values.

Saunders et al include in their research process ‘onion’ (Figure 1.3), the notion of a third research philosophy called ‘*realism*’. This philosophy ties closely to the previously mentioned social constructivism. The distinction between a constructivist and realist approach is that the former believes that people share interpretations of phenomenon based on thought and beliefs, whereas the latter, whilst accepting the subjective basis of social behaviour, also recognise the importance of objective social forces, at the macro-level, that influence behaviour; they argue that realism goes beyond reality and also captures human thoughts and beliefs.

Whilst researchers separate out each of these three schools, there is in practice much overlap between these philosophical positions. Research philosophy represents an elevated, high level, position that a researcher adopts to develop knowledge. Its basis is intellectual rather than practical, influencing the manner in which researchers approach their craft. In the social sciences, phenomena are more unique and less predictable than in the physical sciences, but outcomes may still be generalisable as characterises a quantitative experimental model. Hence, research can often contain elements of positivist, interpretivist and realist approaches integrated together.

1.7.2 Deductive and Inductive Research Approaches

Reliable application of deductive, positivist methods to the world of economics and business is questionable. Unlike the physical sciences, there are fewer ‘absolutes’, such as reliable theories and situations that can be reduced in complexity to a level suitable for testing. One of the biggest differences between the natural sciences and business is that situations or outcomes are usually dependent on both circumstances and people. Circumstances are often unique, which means that they may be quite difficult to recreate or repeat. The unique nature of the subject area introduces a significant level of both unpredictability and subjectivity and often removes the ability to generalise meaningfully except at a superficial level. Acceptance of these points is probably two of the more difficult intellectual hurdles that need to be overcome to employ an alternative research approach successfully.

When all of these features are taken in the round, it becomes evident that there needs to be another approach to research, especially one that does not implicitly rely on scientific theory. An alternative approach does exist and it is generally known as inductive research, focusing on facts and observations; this is often referred to as '*phenomenology*'. In practice, an inductive approach is one that observes and accepts the facts as presented, but also builds up a deeper understanding of what is actually happening rather than presupposing what should be happening.

A phenomenologist pursuing an inductive approach will typically be looking for details and structures behind observed behaviours and outcomes and then interpreting their role and relevance. This may not be a simple concept to grasp but Schein developed a cultural model in the early 1980s, offering a layering within organisations as a useful tool to illustrate the concept.[44] Figure 1.4, below, illustrates three layers, listed as Artefacts and Creations, Values, and Basic Assumptions. On either side of this list are the associated cultural, tangible and intangible organisational attributes and conditions. Each of the three-layers in Schein's model can be explained, thus:[45]

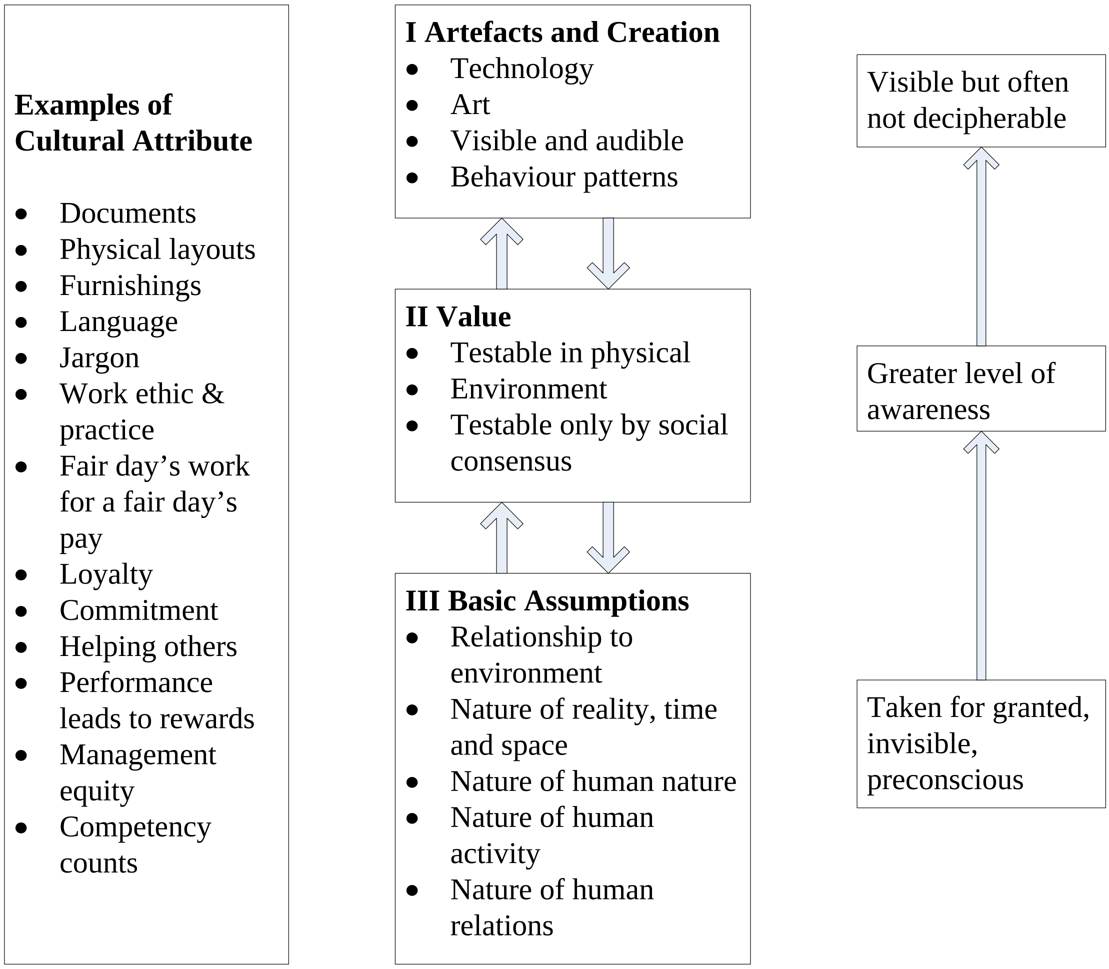
- The first, most superficial, layer has regard to artefacts and creations; that is, things that can be seen or felt, such as technologies, offices or the outward trappings of an organisation.

- The second layer comprises values, requiring a greater level of awareness to understand, such as…'what does our organisation really stand for?' [46]

- The third and final layer is composed of the basic assumptions that are intrinsic to people and organisations. These are not usually visible but are powerful at shaping behaviour, activities and ultimately success. Moreover, the third and deepest layer is not always rational and this is another subjective feature that perhaps denies the application of positivism in this type of analysis.

- Schein's model helps to illustrate the complexities of studying behavioural topics. It is often straight forward to observe phenomena in organisational and business contexts, but there will likely be many cultural and environmental issues that affect decision- making and general behaviour that will be hidden to positive, quantitative analysis. By contrast, a phenomenological and interpretive philosophical methodology will explore and question the intangible human ‘landscape’ that lies behind the physical and macro

Figure 1.4: Schein’s 3-Layer Organisational Model



Source: Schein, E.H. ‘Does Japanese Management Style Have a Message for the American Manager?’ *Sloan Management Review* (Fall, 1981), p64.

organisational environment. ‘*Induction*’ is a powerful tool that essentially builds theory up from the bottom and is based on a wide expanse of observations. Induction usually succeeds in getting a better idea about the context and the feeling of what really makes things happen. Induction tries not to join cause and effect, especially when there is a human interaction at work (and this especially includes the worlds of business, political economy and technology management). Underlying or hidden reasons for behaviours and processes are often the key to an inductive research approach; ‘statistically’ sound generalisations are less important and therefore small sample sets may be used rather than large ones. This technique easily allows alternative theories to be offered, mainly because it does not operate under the constraints of a rigid hypothesis that may only be cherished or discarded after proof or refutation. Theory follows data in the inductive method and this is probably the single most important point that differentiates the method from positivism. Induction is basically an *a posteriori* method, where truth follows from experience and observation.

1.7.3 Research Strategy

There are typically six research strategies available to a social sciences student:

1) Experiment:

This involves the definition of a specific theoretical hypothesis. The hypothesis then makes demands on the selection of samples from populations that have statistical significance. The samples are tested under various experimental conditions where variables are changed scientifically, one-by-one, to determine cause and effect. Measurements are taken in all permutations and conditions and data are recorded for analysis.

2) Ethnography:

This is a rather specialised inductive approach that is based on time-consuming, first-hand observations of behaviour and is especially suitable to the social sciences. The idea is to observe reactions of individuals (usually) in their own environment and this may apply equally to business as to field anthropology.

3) Case Study:

A deeper study of a particular subject allows the development of a much more intensive understanding of that subject. This method is especially important for getting to the bottom of the context of a problem, generating a much richer picture of the set of issues. Standard questions (who, why, and what) are often answered as a matter of course in this approach. There are a number of general methods that can be used including questionnaires, surveys and analysis of documents or the wider body of knowledge.

4) Grounded Theory:

This technique is based on the gradual building up of data into theory. The method begins without an initial theoretical framework (i.e. without an hypothesis), but a theory emerges from the process of aggregation of data and knowledge. Increasing knowledge permits the postulation of ideas that can be tested in turn and any emergent theory remains grounded in the data that have already been collected. In this sense the method is actually a combination of induction and deduction.

5) Survey:

This method relies on the collection of large amounts of data. It is an empirical method for sampling large populations and is based on observation, or, more often, the use of a questionnaire. Care needs to be taken with this method to standardise all the data so that meaningful analysis can be carried out (the problem of comparing ‘apples with pears’ is a common error in surveyed data). Surveying permits a good degree of control over the process, but the range of questions asked might act to deter responses.

6) Action Research:

This method tends to involve the research subjects in the process of research itself. The object of such activity may be a particular institutional problem, which itself may have important ramifications on an organisation if resolved. The focus is on action, as stated in the title, and on outcomes. This method is often applied to the management of change and is rather inductive in nature, compared with a deductive approach, which expects the detachment of the observer from the observed.

1.7.4 Time Horizons

There are two basic types of study that a student may undertake, depending on the timescales available and the desired output of the study:

1) Longitudinal studies:

This method tends to follow a problem right through from inception to resolution. In this sense it is especially suitable for use on problems that are developing over time, or for studying subjects over extended periods in order to assess change in real time. The solution to some change management problems might be effectively managed using this technique, where a researcher can move along with the subjects and assess the success of various interventions. Whilst a longitudinal study may be performed fairly quickly, it is normally associated with longer-term research projects.

2) Cross-sectional studies:

These are typical of comparative studies of organisations within the same industry, across different industries, and sometimes across different economies. Cross-sectional analysis may be characterised as representing a snapshot of the topic at a specific point in time. It is implicit in this time horizons that time is a significant constraint. A successful cross-sectional study is likely to be dependent on the tight articulation of questions if a survey is used, or a good understanding and bounding of the problem being researched if other collection methods are to be employed. Case studies and interviews can also be integrated into this method.

1.7.5 Data Collection Methods

1) Sampling:

This method seeks to secure representative data by researching a scientifically valid number of units from the entire population. The sample can be selected randomly or structured according to characteristics such as organisational size, ownership, public or private affiliation.

2) Secondary data

This refers to the collection of data already in the public domain. Examples of secondary data might involve books, articles, government reports and corporate documents.

3) Observation

As shown in Figure 1.3, this method is closely linked to the research strategy called action research. It is where the researcher enjoys opportunities to observe and record the behavioural characteristics of the units under research.

4) Interviews

Interviews can be structured or semi-structured. The latter are held to be preferable for this study. This is because, while the questionnaires are standardised, the nature of the questions allows the interviewee to develop responses in a flexible way, thus providing additional information and opinion. Interviews should be conducted with individuals possessing the appropriate level of responsibility.

5) Questionnaires:

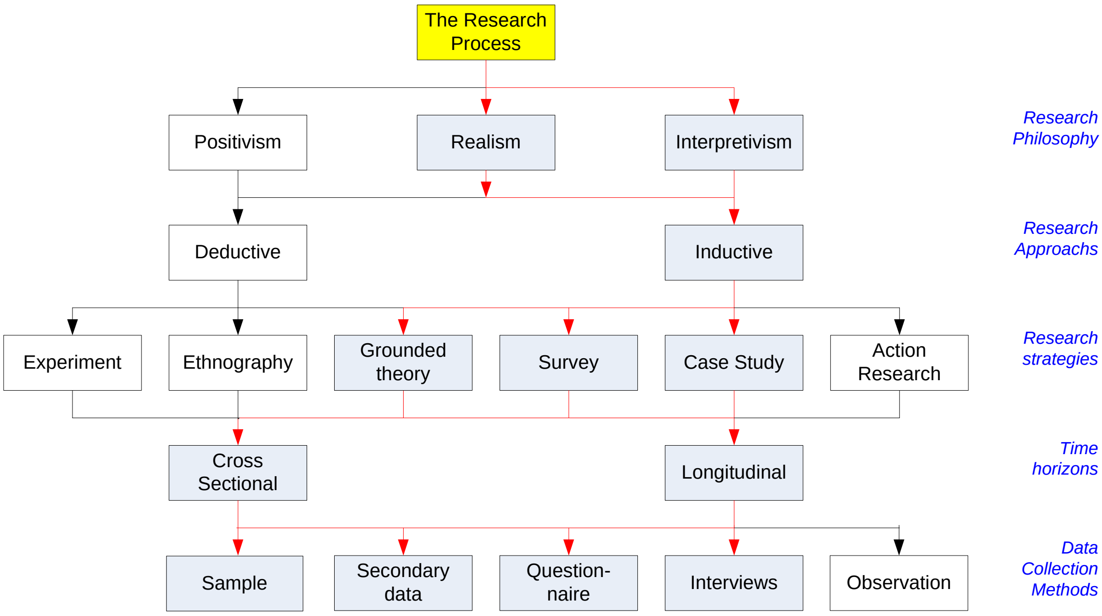
Questionnaires are a useful data acquisition tool, particularly for retaining large amounts of empirical data that can be used for comparative purposes. Questionnaires need to be designed carefully to obtain relevant, specific and original information, as well as aimed at answering the research question. Questionnaires can be used to source both qualitative and quantitative data.

1.7.6 Research Design (Selected Research Methodology)

In the complex world of business and politics it is always difficult to adhere to a single research approach and time horizons; in fact, it may even be counter-productive to do so. In practice most studies tend to use a number of approaches in combination. This has the benefit of covering more ground, permitting the researcher to move flexibly through the study zone and allowing a degree of shift in study aims, data sources, analysis methods and output types. The adoption of a number of different approaches allows the topic to be approached from different angles, including those not pre-selected at the outset. Accordingly, the research methods chosen for this study are mixed and can best be illustrated by adapting Figure 1.3, as shown in Figure 1.5, below. Thus, for Figure 1.5, the research design for the present study is formulated across several layers, including: a realism-interpretivist (phenomenological) philosophical position; a research inductive approach; grounded theory, survey and case study research strategies; time horizons that are both cross-sectional and longitudinal; data acquisition methods that include secondary data, questionnaires and interviews, undertaken on a sampling basis. The shaded boxes indicate the comprehensive research methodology options chosen and the red lines indicate the direction and development of thinking in the design of this study's research method.

The development of a research methodology is described by Yin as the … "first practical step away from the philosophy and theory of research to the design of research."[47] In regard to the present study, research design is critical because the

Figure 1.5: Selected Research Methodology

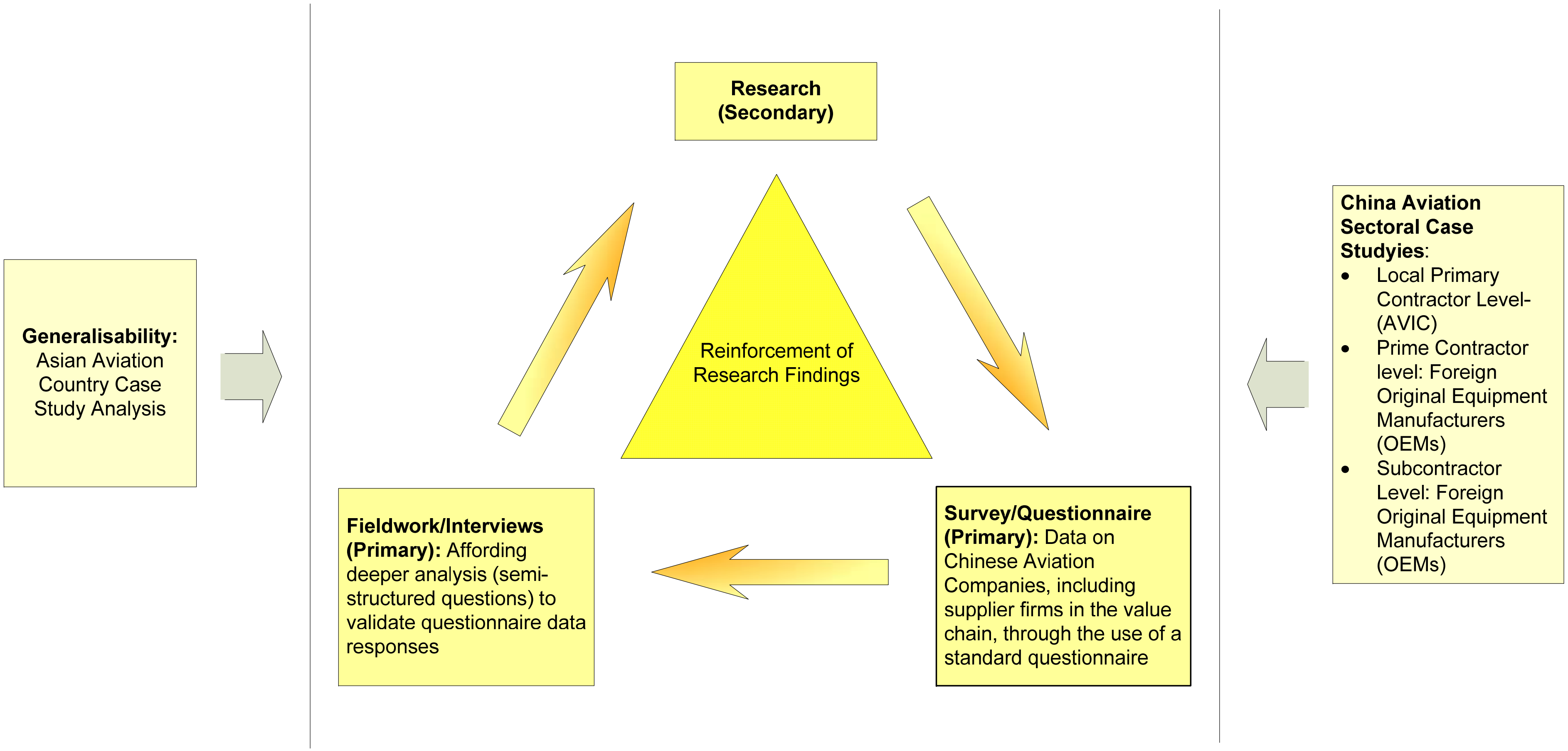


Source: Adapted from Saunders, M. Lewis, P and Thornhill, A, 'Deciding on the Research Approach and Choosing a Strategy', in *Research Methods for Business Students*, Pearson Education (2004), pp 84-112.

'contribution to knowledge' will come from fieldwork in Asia and China. The paucity of data on the nascent aviation industries of Asia and China indicate that empirical investigation is essential, so consideration must be given both to the volume of data (adequacy) and its quality (accuracy). For this reason, the appropriate research strategy for this study is held to be that of the mutually reinforcing 'triangulation' method. Figure 1.6 below, illustrates the three key research elements of this approach, incorporating secondary research, survey/questionnaires, and interviews. The arrows in Figure 1.6 show the progression of the research process, from secondary research to survey and finally to fieldwork interviews.

Secondary Research*:* This is the starting point for data capture in this study. A thorough trawl of literature sources will be undertaken. This will include books, learned journals, specialist publications and quality magazines/newspapers. Web- based searches will also form an important part of the search for secondary material. The author is bi-lingual in Mandarin Chinese and English and therefore extensive searches and interrogation of Chinese material will be supplemented by reports, sector

Figure 1.6: Triangulation Research Methodology Model



Source: author

documents, company Annual Reports and archival papers from fieldwork visits to focused China-based industry associations and Government Departments. Secondary data used in this study will be collected from several sources. Principal amongst these are the:

China Statistical Yearbook;

Almanac of China's Foreign Economic Relations and Trade;

A statistical survey of China; and

Web-site

www.fdi.gov.cn ,

www.xiahua.gov.cn

www.sina.com

http://www.chinaonline.com,

http://en.ce.cn/

www.arj21.org,

www.csaa.org.cn

www.spaceref.com,

http://www.boeingchina.com

http://www.airbus.com.cn/

http://www.bombardier.com.cn/http://www.rolls-royce.com/china/default.htm

http://www.avic1.com.cn/

http://www.avic2.com.cn/

http://www.snecma.com.cn/cs/group/index.html

Survey/Questionnaire:

This part of the research process involves sending questionnaires to companies selected for the survey. The questionnaire was designed around five themes: general data; value-added; supply chain; skills and training; and technological innovation; these themes being sections in the questionnaire. A pilot questionnaire was firstly e-mailed to Ms Chen Qi (Embraer) and Ms Xu Bo (AVIC) to check the completeness and relevance of the questions. Modifications to the questionnaire were made, based on the feedback from the pilot survey. The changes were mostly to remove issues of sensitivity, eg questions on profit from the draft questionnaire. The questionnaire (Appendix 2) was then emailed to several Chinese aviation companies, with responses from four major companies, covering AVIC, Embraer, Safran and Roll-Royce. This response represents something like 70-80% of total output value for China's aviation industry in 2008. Companies not responding to the survey included Boeing, which, whilst a major aviation player in China, does not produce aircraft. It is engaged in a joint-venture aimed at the conversion market, and channels a high level of offsets/subcontract work into Chinese aviation factories; however, to repeat, it does not produce commercial aircraft in China. Similarly, whilst it was disappointing that Airbus did not participate in the interview/questionnaire survey, at the time the survey was conducted, Airbus China was not producing aircraft in China; the output of the A320 had not begun during the survey period (first unit is scheduled to come off the Tianjin assembly line, June/July 2009).

Fieldwork/Interview:

ASIA: To establish whether the China fieldwork findings are consistent and generalisable to other countries in the Asia region, comparative fieldwork was undertaken amongst several ASEAN countries. The choice of countries was determined by preparatory investigation as well as compliance with the countries included in the 'Flying Geese' model, explained fully in Chapter 3. Thus, empirical investigation of aviation firms was undertaken in Singapore, Malaysia and Indonesia, though not in Taiwan (negligible commercial aviation production; mostly military), South Korea (some commercial aviation production, but insignificant compared to military production) and Japan (highly relevant to the Asia survey, but due to Japan's sensitivities over aviation (a strategic industry), the researcher was unable to arrange interviews, at Mitsubishi in Japan). The list of Asian companies visited and personnel interviewed is shown at Table 1.2. Although only one company (PT Dirgantara) visit was conducted in Indonesia, this Bandung company represents 100% coverage for Indonesia's aviation industry. Equally, ST Aerospace represents 100% coverage of Singapore's aviation industry at the local prime contractor level and the survey of three major Malaysia commercial aircraft producers account for close to the total of non-military aircraft production in this country.

CHINA: The fieldwork was conducted in September 2008. At least 2 hours were spent interviewing key executives, including those at director level, at each of China's major

Table 1.2: Asian Aviation Interviews

Company	Country	Name	Title
Singapore Technologies Aerospace Ltd	Singapore	Ho Yuen Sang	Deputy President (Operations)
Rolls-Royce, Singapore	Singapore	Dr Kurichi Kumar	Head, Advanced Technology Centre,
Rolls-Royce, Singapore	Singapore	Dr Nigel Hart	Head, Advanced Technology Centre,
Rolls-Royce, Singapore	Singapore	Mr Jonathan Asherson	Regional Director-South East Asia
Economic Development Broad	Singapore	Ms CHAN Ying Xuan	Assistant Head, Transport Engineering
SME Aerospace Sdn.Bhd.	Malaysia	Mr. Chee Eng Boon	Chief Executive Officer
Ministry of Defence, Malaysia	Malaysia	Dr Kogila Balakrishnan	Principal Assistant Secretary, Defence Industry Division
BAEs System (Internatinal) Ltd	Malaysia	Mr Richard McKie	Director-Industrial & Business Development
Composities Technology Research Malaysia Sdn Bhd	Malaysia	Mr. Azizi Azizan	Corporate Communications Business Development
Composities Technology Research Malaysia Sdn Bhd	Malaysia	Mr. Zulkarnain Mohamed	Senior General Manager
Eurocopter	Malaysia	Mr. Syed Abdul Rahman Alhadad	Senior Director, Quality, Flight Operations and Training
Eurocopter	Malaysia	Mr Mohd Nizam Mohd Arop	Manager Public Relations and Corporate Communications

EADS	Malaysia	Ms Jamaliyah Ambia	Director of Marketing
Malaysian Industry-Government Group for High Technology	Malaysia	Mr Maj Zailani Safari	General Manager Strategic Technology
Malaysian Industry-Government Group for High Technology	Malaysia	Mr Lt Col Ir Kamarulzaman Zainal	Vice President - Intelligence & Research
Malaysian Industry-Government Group for High Technology	Malaysia	Mr. Shamsul Kamar Abu Samah,	Manager Intelligence & Research
Agusta Westland	Malaysia	Mr Peter Richings	Regional Business Executive Sales & Marketing
PT Dirgantara Indonesia/Indonesian Aerospace	Indonesia	Mr. Sonny Saleh Ibrahim	Vice President Technology Business Center
PT Dirgantara Indonesia/Indonesian Aerospace	Indonesia	Mr Gusti Naurah Sudira	Supervisor of Technology Cooperation

Source: author

aviation companies, except for Boeing, Airbus and Bombardier. The impact and development of these companies was covered, to a large extent, by interviews with independent aviation consultants and specialists. At the meetings, every opportunity

was taken to cross-check the data included in the completed questionnaire, by directed, but nevertheless, open-ended discussion, allowing the interviewee the flexibility to go ‘off-script’ and develop more detailed responses. Interviewees often brought along discs and ‘internal’ hard copy reports to support the interviewer’s data collection efforts. Research and education are accorded a high priority in China and Asia generally, and for those company executives interviewed, there was a willingness to support the fieldwork. Table 1.3 provides a list of executives/specialists interviewed in China. All the interviews were conducted at the respective company headquarter in Beijing, given the Chinese authorities’ reluctance to grant site visits to the ‘sensitive’ aviation factories. The list of China companies/originations contacted and personnel interviewed is shown at Table 1.3. Data acquisition is thus a combination of secondary research, survey questionnaire (the draft survey questionnaire is shown at Appendix 2) and interviews. The questions are open and broad, encouraging interviewees to extend discussion beyond narrow parameters, embracing issues of wider relevance.

Table 1.3: China Aviation Interviews

Company	**Coun -try**	**Name**	**Title**
Embraer China	China	Mr Guo Dong Yuan	President, Embraer China
Embraer	China	Ms Chen Qi	Director of Communications, Embraer China,
Embraer	China	Mr Xiao Fusheng	Advisor, Embraer China,
China Aviation Industry Corporation II	China	Ms Xubo	Director, Aero-products Division
China Aviation Industry Corporation II	China	Mr. Xia Qunlin	Director General, International Cooperation & Trade Department
China Aviation Industry Corporation II	China	Mr. Wang Wenfei	Deputy Director General, Aircraft Department,
China Aviation Industry Corporation II	China	Mr. Jiang Yunsheng,	Director, AVIC II Planning Department
Rolls-Royce International Limited-China	China	Dr Guangqiu Wang	Director of Business development
Rolls-Royce International Limited-China	China	Mr Richard Margolis	Regional Director, North-east Asia
Safran China Representative office	China	Dr NI Jingang	Deputy Chief Representative
China Aviation News	China	Mr. Rong Weiren	Reporter
International Aviation Group	China	Mr. David Xu	Chief-in Editor

Source: author

The triangulation research model is premised on the need to achieve data adequacy and accuracy to support empirical analysis of the strategic and high profile, but relatively unexplored, Chinese aviation industry. The strong mixture of research strategies, time horizons and data collection methods will provide confidence that the research results are valid and generalisable. The triangulation metaphor is taken from navigation and military strategy, which use multiple reference points to locate an object's exact position. [48] Triangulation thus seeks to obtain confirmation of findings through convergence of different perspectives; the point at which these converge is seen to represent reality.[49] The triangulation method was employed during fieldwork in China and the Asian countries. Its purpose is aimed at reducing interviewer bias and validating data accuracy. The use of secondary data sources, including corporate archival material is a broadly accepted approach in social sciences research. Similarly, the use of the survey questionnaire techniques alongside a mixture of informal and standardised interview models is deemed legitimate.[50] It is possible to explore the same research question using both techniques, although one tool may be more appropriate than the other depending upon a number of issues: time and money; sampling criteria and the population being researched; and the type of data being uncovered.[51] Interviews provide the opportunity for deeper research and are held to result in a higher quality of measurement.[52]

The Asia fieldwork offers a comparative evaluation of China's technology development experience, allowing the opportunity to check for consistency. For instance, the nature of technology access challenges industrialising countries face. As can be seen from Figure 1.5, the China fieldwork is an attempt to explicitly research the differing contextual problems and challenges faced at three sectoral levels, namely, the prime local contractor, prime foreign contractor, and foreign subcontractor level. This approach is similar to undertaking a multiple case study approach, which can be defined as … "an empirical inquiry that investigates a contemporary phenomenon within its context and in which multiple source of evidence are used."[53] Moreover, the study of a 'case' can be a study of *n* cases depending on the subject under study.[54] Thus, in the fieldwork of China's aviation industry, multiple case studies have been undertaken of the foreign aircraft/subsystems manufacturers in China as a means of evaluating the technology transfer/development experience, both within and between each of the cases.

1.8 Study Structure

Following this introductory chapter, there are five further chapters to this study. Chapter 2 provides a critique of the literature on industrial and technological development. The purpose of chapter 2 is to highlight the theoretical issues relevant
for the later empirical investigation of Asia and China's progress in indigenous aviation production. Discussion in chapter 2 centres on the theoretical evaluation of importing, infusing and indigenising foreign technology and is structured around the 'fully' developed conceptual model at Figure 2.10 for analysing the applied issues in subsequent chapters. Chapter 3 begins this applied analysis by exploring Asia's development performance in the promotion of local aviation capacity. A well-known academic study framework has been employed to examine the process of technology transfer and development at the Asia regional level. Termed the Flying Geese Model, it depicts Japan as the technology leader, with the other Asian countries as followers or latecomers to industrial and technological development. The empirical investigation in this Chapter sets the stage for evaluating the focused case study of China in Chapter 4. Here, as per the venn diagram shown at Figure 1.2, China's development at the macro-level is examined. To begin, there is an analysis of China's industrial development through the 'curse' of centralisation over the first 30 years of Communism. From collaboration with Soviet Union to the catastrophe of the Cultural Revolution, China's development path was anything but smooth. The analysis focuses on technology planning during the post-1978 'open-door' period. This period is characterised by the growth of inward FDI and associated technology transfer, kick-starting China's industrial and technological push. Finally, the chapter focuses on Technology development, both in general terms, but importantly also in regard to the fledging aviation sector. The discussion centres on the origins of the aviation industry and on the early policy emphasis given to military aircraft production. Following this discussion, an examination of China's recent policy initiatives and practical achievements will be undertaken as a means of providing the building-blocks for later analysis of the progress achieved in indigenising commercial aviation production. This is undertaken in Chapter 5, where the study becomes firmly directed forwards development of China's aviation sector, recognised formally as a strategic industry. Here, the particular challenge of promoting strategic industries will be explored, focusing particularly on the

technological development of the aviation industry. The thrust of this chapter is to evaluate the effectiveness of technology transfer through both FDI and offsets investments. By reference to the extended conceptual model shown at Figure 2.10, chapter 5 examines the success of the industry's technology absorption capacity. Thus, by analysing several pre-determined I^2 metrics, the chapter seeks to establish the extent and nature of technology 'deepening' rather than simply the 'broadening' of the technology base. The closing chapter 6 will specify conclusions and policy recommendations with the purpose of drawing together all strands of the discussion and analysis. The underlying goal of this thesis is to advance knowledge and promote policy improvement, inviting other interested observers to make their own contribution to this important debate.

References and Notes

[1]Xiahua Net http://news.xinhuanet.com/english/2009-03/05/content_10951930.htm downloaded on 17 April 2009

[2] World Bank statistics, http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20399244~menuPK:1504474~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html, downloaded on 17 April 2009.

[3] World Bank statistics http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20399244~menuPK:1504474~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html download on 17 April 2009.

[4] WTO http://www.wto.org/english/news_e/pres08_e/pr520_e.htm downloaded on 17 April 2009.

[5] WTO http://www.wto.org/english/news_e/pres08_e/pr520_e.htm downloaded on 17 April 2009.

[6] WTO http://www.wto.org/english/news_e/pres08_e/pr520_e.htm downloaded on 17 April 2009.

[7] Ideologically, during the 25 years following the founding of Communist China, the use of foreign capital, especially FDI, was regarded as contradictory to the Communist cause. It was regarded as begging from capitalist countries and in the process 'losing face'.

[8] On the cultural importance of 'face' in China, see: Graham, J.L and Lam, N.M, 'The Chinese Negotiation', *Harvard Business Review*, October, 2003, pp82-91, and Selmer, J, *International Management in China: Cross-cultural Issues*, Routledge Publishing 1998. Note that 'enhancing' face is as important as 'losing' face.

[9] Due to historical, ideological and political reasons, FDI into China was minimal across 1949-78. China had to turn to the USSR when western countries embargoed trade with China. See, Yingqi Wei and Xiaming Liu, *Foreign Direct investment in China: Determinants and impact*, Edward Elgar 2001.

[10] One of the major paradoxes in China's development strategy is that at the same time as Beijing was 'opening-up' its economy by, for instance, joining the WTO, it was maintaining its policy position of seeking economic self-sufficiency.

[11]Factbox: China per capita view, http://news.xinhuanet.com/english/2009-04/02/content_11121175.htm, (14 April 2009)

[12] Ibid.

[13] 'Bulls in a China Shop', *Economist* , March 20 2004, P9.

[14] UNCTAD http://www.unctad.org/Templates/webflyer.asp?docid=9439&intItemID=1528&lang=1.

[15] See Furtado, C, *Development and Underdevelopment*, University of California Press, 1964.

[16] UNCTAD estimate, 2002.

[17] Provisions of the State Council of the People's Republic of China for the Encouragement of Foreign Investment , October 1986.

[18] The Open Door was a trade policy designed to persuade China to open its market to the rest of the world while calling on the European powers and Japan to accept 'perfect equality of treatment for navigation and commerce' for all countries trading with China. For an elaboration of the formulation of the Open Door Policy, see, for example, Warren I. Cohen, *America's Response to China*, New York: John Wiley & Sons, 1971,pp46-52.

[19] The Kuomintang government established aircraft repair factories at Hangzhou, Shanghai, Nanjing and Wuchang, and in the 1930s, copy production and assembly of aircraft were pursued in joint ventures with the US and Italy. In 1950,Premier Zhou announced the 'guiding principle' for the development of China's aircraft industry: 'from repair to copy production and then from copy production to design and manufacturing, Jee, Duan, Zet al (eds*) China Today: Aviation Industry*, China Aviation Industry press, Beijing 1989, p1.

[20] The priorities of modernisation were ranked accordingly, with national defence seen as the least important.

[21] Deng Xiaoping's emphasis on path-breaking economic reform and opening-up of the Chinese market to the world economy sought to reinforce policy priorities away from defence and instead towards economic development.

[22] UNCTAD, The Interrelationship Between Investment Flows and Technology Transfer: An Overview of Main Issues, UNCTAD/ITD/TEC/1 United Nation, General, 24 November 1992.

[23] The 1979 Act allowed FDI to be approved by government if the investment benefitted China; it ensured international firms legal rights and defined a minimum 25 percent of foreign equity, but did not define a maximum.

[24] In 1986, the Chinese Constitution explicitly permitted … 'foreign enterprises and other economic organisations or individuals to invest in China under conditions prescribed by laws of the People's Republic of China, to cooperate in a variety of forms with Chinese enterprises or other economic organisations. . . Their legal rights and profits are protected by the laws of the People's Republic of China. During the 1980s a variety of laws, including laws to protect patent rights, were added to regulate FDI and the State Council endorsed a number of administrative orders to reinforce their implementation. In particular, in 1986, the State Council publicised 22 principles, entitled The Rules for Encouraging Foreign Investment in China, which gave privileges to enterprises exporting products and using advanced technologies.

[25] On December 1, 2002, China for the first time allowed private and foreign investors to acquire controlling stakes in domestically listed companies. MOFTEC website: www.moftec.gov.cn (accessed July 2003).

[26] 'Annual FDI to China to hit US$100 billion', *Emerging Markets Economy*. London: Jan 5, 2003. p1.

[27] 'Annual FDI to China to hit US$100 billion', *Emerging Markets Economy*. London: Jan 5, 2003. p1.

[28] Stone, T, 'Pragmatic for the People', *Financial Management,* October 2003, p22.

[29] Stone, T, 'Pragmatic for the People', *Financial Management,* October 2003, p22.

[30] Sourced from, Ministry of Commerce of the People's Republic of China ,http://www/fdi.gov.cn, July 2009.http://www.fdi.gov.cn/pub/FDI/wztj/lntjsj/wstzsj/2007nzgwztj/t20081110_99059.htm.

[31] For instance, in 1996, Beijing identified several sectors as having 'pillar' status, eg machinery, electronics and petrochemicals, providing $60b through to 2000 for the development of these industries. In 1998, the state planning commission named 18 high tech industries that would gain duty free status on capital equipment imports.

[32] For instance, a guideline was published in March 1995, detailing the government's intention to promote FDI in Microelectronic production along with several other high tech sectors.

[33] Shively identifies two types of research types in the social sciences: 1) applied or basic and 2) non-empirical or empirical. The present study's research approach is applied-empirical. See, P.W Shively, The *Craft of Political Research*, New Jersey: Prentice-Hall (1990).

[34] Quoted by Zhu Lilan (ed) in S*cience and Education for a Prosperous China*, CPC central party School, 1995.

[35] For instance, across the period 1955-75, the number of local patents issued in India for machine tools designed to cut and work metal was just 15% of the total patents issued in the country. See, Matthews, R, *Industrial Strategy and Technological Dynamism in Machine Tool Manufacture-Comparative Perspectives on Indian and Japan*, Research policy Institute, University of Lund, Sweden, 1982, p33.

[36] See, Matthews, R, Industrial Strategy and Technological Dynamism in Machine Tool Manufacture-Comparative Perspectives on Indian and Japan, Research policy Institute, University of Lund, Sweden, 1982, pp31-36.

[37] See, for instance, Chinworth, M and Matthews ,R, 'Defence Industrialisation Through Offsets: the Case of Japan,' Martin, S(ed) *The Economics of Offsets: Defence Procurement and Countertrade*, Harwood, Academic Press, 1996.

[38] The classic book in this regard is Samuels R, *Rich Nation, Strong Army: National Security and the Technological Transformation of Japan*, Cornell University Press, 1994. An example of Japan's continued technology 'catch-up' has regard to Tokyo's efforts to develop an indigenous aerospace equipment sector. It has sought to achieve this through international technological collaboration as, for instance, in the multinational development of the V2500 turbo-fan jet engine, and international strategic alliances, as in the case of Mitsubishi's full partnership with Boeing in the development and production of civil airliners, eg the triple 7 programme.

[39] Smith, A, *Wealth of Nations,* Oxford University Press, 1998, p292.

[40] Many of the successful industrialising Asian countries have adopted this development approach. See, for instance, Matthews, R, '*Singapore's Defence Industrialisation Strategy*', *Asia-Pacific Defence Reporter*, Australia, December 1999.

[41] Saunders, M. lewis, P and Thornhill, A 'Deciding on the Research Approach and Choosing a Strategy', in *Research Methods for Business Students,* Pearson Education (2000) pp 84-112.

[42] See Collins, J. Hussey, R, *Business Research*, Palgrave 2003.

[43] See, Remenyi, D. Williams, B Money, A and Swartz, E Doing Research in Business and Management: An introduction to Process and Method, Saga publications 1998.

[44] See Schein, E.H. 'Does Japanese Management Style Have a Message for American Managers?' *Sloan Management Review,* Fall, 1981.

[45] Schein, E.H. 'Does Japanese Management Style Have a Message for the American Manager?' *Sloan Management Review* (Fall, 1981) p64.
[46] Schein, E.H. 'Does Japanese Management Style have a Message for the American Manager?' *Sloan Management Review* (Fall, 1981) p30.
[47] See, Patton, 1990, access from http:// owl.english.purdue.edu/owl/resource/559/01/ - 58k 15 April 2009
[48] See Clark, D, 'Relationships Between Theory-Driven Empirical Research in Operations Management and other Disciplines', *Journal of Operations Management* Vol.16, pp341-59.
[49] Jack, E and Raturi, A, 'Lessons Learned From Methodological Triangulation in Management Research, *Journal, Management Research News*, Vol. 29, No 6 (2006) p345. Also, in relation to overcoming problems of bias and validity, see Oppermann, M. 'Triangulation – A methodological Discussion', *International Journal of Tourism Research*, Vol. 2 (2000), p143.
[50] However, the interviewer should be objective, reduce voluntary or involuntary interviewer bias in questions asked, and ensure interviewee cognition; that is a full understanding of the question being asked. On the conditions of successful interviews, see Lisa Harrison and Wolfgang Deicke, Chapter 6, 'Conducting Interviews in Political Research', Harrison, L, (ed) *Political Research*, Routledge (2001) p96.
[51] Ibid., Harrison, L and Deike,W, p90
[52].Monro, A, *Essentials of Political Research*, Westview Press (2000), p71.
[53] See Robert Yin, R. *Case Study Research: Design and Methods*, Sage Publications, (1994).
[54]See, H, Ekstein, 'Case study and Theory in Political Science' in F. Greenstein and N, Polsby (eds) *Handbook of political Science*, Addision-Wesley (1975), Vol. p7.

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Chapter 2 Achieving Economic ‘Take-off’: the Challenge of Transferring, Absorbing and Indigenising Technology

2.1 Planning for Development: Can Success be Transferred?

All countries seek economic development, but the question is how can this be achieved? Adam Smith in his 1776 treatise entitled: *An Enquiry into the Nature and Causes of the Wealth of Nations*, argues that the most efficient form of economic advancement is through the market mechanism.[1] Market forces (supply and demand) act via an ‘invisible hand’ driving resources to the growth poles of an economy. This is known as Capitalism. It is a model demonstrating that consumer sovereignty is exercised through choice, with suppliers striving relentlessly to maximise profit.

Although Adam Smith’s ‘perfect markets’ model informs contemporary policymaking, it is nothing more than an ideological construct. In reality, demand functions are not horizontal, industrial consolidation occurs continuously, proprietary information is protected, and product differentiation is a major business preoccupation. Capitalism is an aggressively competitive business where firms seek to remove their rivals from the market. Thus, through seeking competitive edge, the long-term corporate goal is aimed at evolving monopoly positions and dominating the market. It is a process of economic transformation. In a highly dynamic market-based environment, where the role of government is limited, investment will gravitate towards those sectors enjoying high demand and profit. On this basis, Smith argued that microeconomic competitiveness provides the foundation for macroeconomic success (defined traditionally as high economic growth, low inflation, high employment and a balance of payment surplus).

However, the problem with Adam Smith’s model for most underdeveloped countries is that Capitalism is often inappropriate for ‘initiating’ the development-push. By definition, poorer countries are capital-scarce and labour-abundant. Capitalism, therefore, exposes a developing country to the dual dangers of high risk and distant returns. There is also the possibility of surplus supply and thus capacity under-utilisation where capital-intensity is low and market access high. As a consequence, governments inevitably have to intervene in poorer countries to kick-start the development process. Such interventionism spans the spectrum of selective promotion of strategic economic sectors to full-blown Communism.

These introductory comments suggest that the development of underdeveloped countries poses challenges distinct from those of the already advanced countries. If correct, then policies need to be crafted and aligned to the development status a country has reached. Accordingly, the purpose and structure of this chapter is to profile the process of economic development against the conceptual model shown at Figure 1.2 (Chapter 1). Stage I of the development cycle is development planning, highlighting the identification and selection of development plans appropriate for promoting local industrial and technological development. Thus, to begin this chapter, the scene is set by evaluating the traditional development models. Whether the politico-economic context is Capitalism or whether it is the command economy, a common thrust of these development models is that of seeking to propel economies into self-sustaining economic growth. Through a stage-process approach, development conventionally requires industrialisation and thus diversification away from dependence on agricultural cash crops. Industrialisation is founded on manufacturing and a host of associated conditions, including the generation of higher quality skill-sets, increased productivity, and also promotion of positive cultural attributes.[2] However, perhaps the most important aspect of industrial success is technology. This begs the question, however, as to how best to access technology?

Stage II in the development cycle is technology planning. This has regard to determining how best to source the technologies required to foster industrialisation. For ‘late-comer’ countries, the government takes the lead by adopting an interventionist strategy to initiate technological development. Chapter 2 thus explores the historical experience of major industrialising countries/regions, identifying their respective macro-level technology strategies. Western, Soviet, African and Asian technology politico-economic planning frameworks are examined to provide the broad context for a detailed evaluation of the sources of technology acquisition.

Stage III, the final stage of the development cycle, concerns the role of government in implementing policies designed to accelerate industrialisation through the promotion of strategic industries. Of relevance here is the process of technological upgrading, examined by reference to Asia's 'flying Geese' model.[3] In this regard, 'lead' or 'strategic' sectors will be defined and the role of 'dual-use' technologies in industrialisation evaluated. Discussion will focus on technology access in the modern era, However, foreign investment involves costs as well as benefits. Thus, to close discussion in this second stage of the development cycle, a critical analysis of the costs and benefits of FDI is undertaken.

2.2 Development Planning: The initial Development Push

Development planning is today a necessary precursor to the development of underdeveloped economies. Government has an important role to play in this process, irrespective of the politico-economic model countries pursue. Government normally adopts an interventionist strategy, directing resources according to some pre-determined plan. This might focus development on strategies such as import-substitution or export promotion, balanced or unbalanced growth and consumer goods-led or capital goods-led models to transit from agricultural to industrial economies. Although the development literature recognises these different approaches, the policy impact is weakened because the writings have been customised by Anglo-Saxon economists to replicate the conditions in the advanced countries. This is obviously inappropriate for the poorer countries, and was long ago recognized as such by Dudley Seers, who argued that …"the economics of development must have more direct relevance to the problems of the less developed countries."[4] To overcome this theoretical and policy remoteness, both modification and extension of traditional western economic theory is required. This does not mean that traditional theory has no value, but simply that it is necessary to modify conventional economic theory. It is clearly important to take account of particular circumstances that alter the institutional framework and cause behavioural relationships to differ in the poorer countries from what they would be in the more advanced economies.[5]

2.2.1 Development 'Stage' Models

As a means of tailoring theory to the unique challenges faced by developing economies, academics have mused over the transition process, from poor to rich, in terms of a uni-directional pattern of stages. Adam Smith, was perhaps the first writer to classify the stage-process, referring to the development sequence of hunting, pastoral, agricultural, commercial, and manufacturing stages.[6] Karl Marx progressed this thinking, arguably in a more radical way, to examine the stages of Feudalism, Capitalism, Socialism and Communism.[7] Of course, critical to the Marxian framework is the crisis of Capitalism, whereby the proletariat overpower the Capitalist class and take ownership of the means of production. Marxists argue that autarchy under the command economy model can be legitimised, because the government is the people and the people is the government.

At the other end of the politico-economic spectrum is Rostow's 1959 stage model.[8] Rostow attempted, heroically, to generalise the 'sweep of modern economic history' in a set of five stages of growth,[9] as illustrated in Figure 2.1. These stages are designated as follows: traditional society; pre-conditions for take-off; take-off; the drive to maturity; and the age of mass-consumption.[10] For Rostow, the 'take-off' into self-sustaining growth was the pivotal factor in his schema. He defined take-off as …

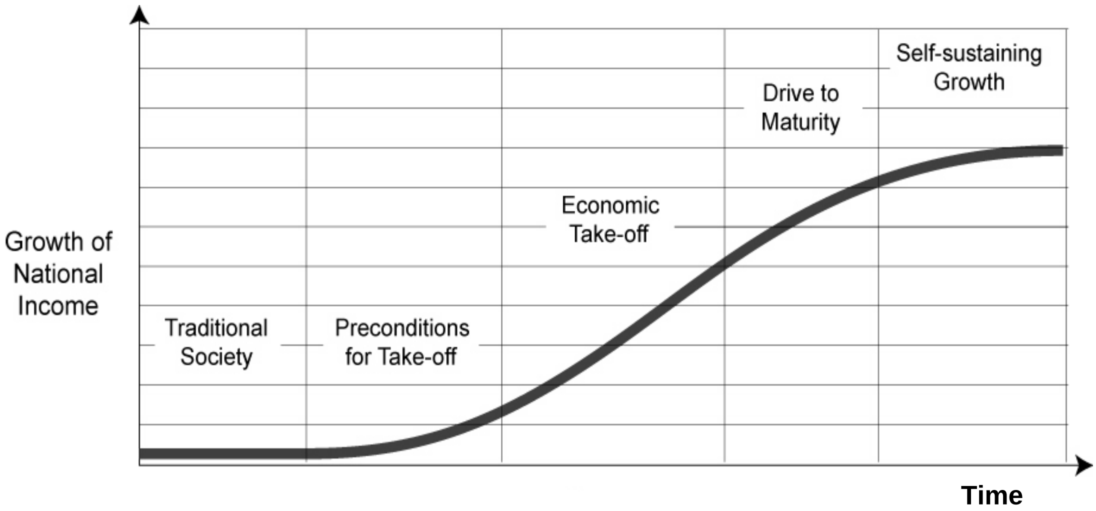
> "a decisive transition in a society's history…[a period]… when the scale of productive economic activity reaches a critical level and produces changes which lead to a massive and progressive structural transformation in economies and the societies of which they are a part, better viewed as change in kind than merely in degree."[11]

For take-off to occur, Rostow argued that three conditions must be fulfilled:

- The rate of productive investment must rise to at least 10 percent of national income

- Development with a high rate of growth must occur in one or more of the substantial manufacturing sectors
- Political, social and institutional frameworks must be put in place to ensure that economic growth has an on-going character.[12]

Figure 2.1: Rostow's Stage Model



Source: Rostow, *The Stages of Economic Growth*, Cambridge: Cambridge University Press, 1960.

Rostow's thesis generated considerable debate, activating a broader discussion as to the value of identifying 'stages' in the development process. Kuznets, for example, criticised the uni-directional, non-cyclic, development process, whereby a stage materialises, runs its course, and never recurs.[13] Thus, even in the process of devolution and decline, the return to a level experienced previously is first viewed as a recurrence of the earlier stage. The critical issue asked by Kuznets is how such a simple design can be a summary description or analytical classification of a vast and diverse field of historical change.[14] For instance, Marx's analysis of the 'March of history' appears rigid and arbitrary, generalising Britain's take-off to the development experience of all countries.[15] Similar criticisms can be applied to Rostow's thesis, particularly the linearity and generalisability of the stage-sequencing. Stages may be skipped, though this may be difficult to establish and sequencing may be blurred.[16] The problem is that stages are not mutually exclusive and the characteristics of earlier stages may become mixed with those of later stages. However, notwithstanding these criticisms, the writings of Smith, Marx and Rostow have helped focus analysis on four important development attributes: the dynamics of production; the 'strategic' issues constituting the necessary and sufficient conditions for determining the transition of economies from one stage to the next; the role of government in creating institutional frameworks; and, finally, the significance attached to 'lead' manufacturing sectors. Manufacturing was recognized as the zenith of development by all stage theorists. For Smith, manufacturing is the final stage. Equally, Marx viewed it as the defining moment, representing the transitional stage where ownership of capital becomes divorced from its use. Finally, for Rostow, the development of manufacturing capacity is the mechanism for achieving successful economic take-off. However, although manufacturing is a lead sector, there is uncertainty as to whether some industries within the broader area of manufacturing are more 'strategic' (possessing greater economic centrifugal forces) than others.

Rostow's focus on the ultimate goal of promoting manufacturing development is closely aligned to two further separate schools of development; one favouring balanced industrialisation and the other favouring an unbalanced approach. Balanced growth runs counter to Rostow's model, because the latter emphasises targeting investment on lead sectors rather than a broad-based investment strategy. By contrast, proponents of balanced growth advocate that investment decisions are mutually reinforcing and that, as the classical economist Jean Baptise Say once argued … "supply creates its own demand."[17] Such arguments have an intuitive appeal, particularly during the initial phase of industrial development. Moreover, the logic of balancing investment across a number of different industries is self-evident. Judicious capital injections ensure that the capital-labour ratio is increased, enhancing worker productivity. Also, importantly, these workers become each other's customers. In this way, a pattern of mutually supporting investment in different lines of production can enlarge the size of the market and help to fill the vacuum in the domestic economy of low productivity and low income activities.

Compared to balanced growth theory, Rostow's model represents an entirely contrary approach to industrialisation in the sense that a single industry, or limited cluster of key industries, is the source from which an initial acceleration of income and investment radiates across the economy. Such lead sectors often have three pathways of impact (linkages) on the local economy: forward, lateral and backward. As discussed later in this chapter, the nature of the lead sector and the impetus provided to the emergence of supplier industries is a key determinant not just for economic take-off but also for self-sustaining development.

Rostow's notion of forward, lateral and backward linkages and the role of 'leading sectors' resonates with the views of the unbalanced growth theorists. Central amongst these is Hirschman.[18] His view is unequivocal that investment must concentrate on those industries most conducive to transforming the economy to a higher stage. Hirschman maintains that this is preferable to dissipating scarce investment funds by attempting to advance on all fronts at the same time.[19] This is highlighted by Wilber's metaphor … "to be breathlessly climbing a peak in a mountain range is…more important than standing poised on the crest of a ridge in the foothills."[20] Pre-dating the work of Rostow, Hirschman documented the important external economies that would be generated by a country investing in those industries exhibiting high linkage effects. He laid emphasis on two of the three types of linkage: (i) the 'input' provision or backward linkages, and (ii) the 'output' utilisation or forward linkages.[21] From a development perspective, Hirschman argued that backward linkages have the greater stimulative effects. The advantage of an industry with high backward linkages relates to the part it plays as an inducement mechanism to the development of a feeder-network of ancillary industries. If the expansion of a particular industry leads to a general increase in economic activity, embracing a considerable number of subsidiary and basic industries, then it must be classified as a key industry, meriting a high development priority.[22]

Hirschman's interpretation of leading sectors not only emphasises the importance of triggering a quantitative demand response from supplier industries (backward linkages) but also highlights the lead sector's role in cultivating new techniques and technologies. Lead sectors are therefore likely to be modern, innovative and knowledge-intensive industries. Technological diffusion and development are likely to become more powerful forces, as the economy's absorptive capacity improves. The important role of capital accumulation and technology in both the Rostow and Hirschman 'lead sector' approach is encapsulated in the development of the Harrod-Domar growth model.[23]

2.2.2 Harrod-Domar growth model

At the heart of the Harrod-Domar model is a simple but powerful equation. It seeks to explain the growth process as:

$$\Delta GDP = \frac{S}{C/O}$$

Where: ΔGDP represents a change in national income

S is the savings-income ratio

C/O is the capital-output ratio

The variables in the Harrod-Domar growth model show that economic growth (ΔGDP) is dependent on a:

- Rise in the savings-income ratio, providing the financial resources for quantitative and/or qualitative increases in capital investment; and/or a
- Decline in the capital-output ratio, indicating a reduction in the amount of capital investment required to produce one unit of output.

The Harrod-Domar model is thus important in defining the basic condition for developing countries to actualise economic growth. For growth to occur, capital is a necessary but not sufficient ingredient. Also important is the imperative to use capital efficiently, an important attribute of the 'leading sector' thesis.[24] By definition, lead sectors have a strategic role to play in the growth and development of the host economy. Hence, improvements in the product and process technologies in such industries will have a significant impact on the pace of upstream and downstream industrial and technological development. Arguably, then, the technological strength of lead (or strategic or pillar) sectors can play an important role in initiating and sustaining economic take-off. Technology planning models have been conceptualised to explore the important contribution that high technology lead sectors can make in the industrialisation process. As discussed below in section 2.3, these models emphasize the strategic significance of lead industrial sectors, both at a point in time and by geographical context.

2.3 Technology Planning for Appropriate Technological Acquisition

Developing countries seek to diversify their economies away from dependence on agriculture. The creation of Five-Year Plans provides the policy approach for investment into pre-determined industrial sectors. The aspiration is to evolve a dynamic comparative advantage that brings the advantages of high growth, skill-generation and robust export performance, as well as other economic benefits absent in agricultural production.

However, transition from agricultural specialisation towards industrialisation requires technology planning, a vital stage in the search for indigenous capability. Traditionally, the principal sector in an industrial economy is manufacturing and this is unlikely to develop without access to technology. To drive the initial industrial push, 'hard' technology (physical capital, such as machinery) will need to be imported from the advanced countries to facilitate local production. Yet, this is just a first step. To secure progress towards industrial and technological self-reliance; that is, industrial indigenisation, it is essential that 'soft' technology (investment into human capital, such as the development of research and design capacity) also be created in-country. Technology planning aims to identify the strategic frameworks and technology acquisition and implementation options for progressing technological development.

Surprisingly the role of technology in development has only recently attracted theoretical attention. Classical economists, such as Smith and Ricardo, did not recognize the importance of technology in their theoretical models.[25] For both, the key issues were labour productivity, economic specialisation, and the existence of 'free' markets. At the international level, Ricardo developed Smith's theory of absolute advantage to examine what he termed comparative advantage.[26] Ricardo advocated an international division of labour, based on the comparative advantage of production and measured according to relative labour productivities. Capital was held to be immobile, constrained to the host economy. Ricardo argued that if international trade operated according to his comparative advantage theory, then, compared to the pursuit of self-sufficiency, national output would be maximised. Thus, if all countries produced and exported on the basis of their comparative advantage, global welfare would be maximised.

Two points need to be noted in relation to the classical comparative advantage theory. Firstly, the theory indicates that international specialisation should occur with the much later 1950's Heckscher-Ohlin model, arguing that the pattern of trade should reflect factor proportions. [27] Accordingly, a capital-abundant country will export capital-intensive goods, while a labour-abundant country will export labour-intensive goods. The critical assumption in this model is that the two countries are identical, except for the difference in resource endowments. This is also implies that the aggregate preferences are the same. The relative abundance of capital will cause the capital-abundant country to produce capital-goods cheaper than the labour-abundant country, and vice versa. The second point in relation to comparative advantage theory is that it is static in nature, reflecting the given specialisation of particular countries. It implies, for instance that 1950's Singapore ought to have specialised in rice production, trading with, say, Europe for manufactured goods. This, of course, would have been unacceptable to Singapore. Indeed, all governments seek to evolve a 'dynamic' comparative advantage through import-substituting industrialisation. Whether this specialisation is biased towards consumer-goods or capital-goods industrialisation is unimportant. What is important is that government makes a conscious policy-decision to diversify its economy away from dependence on cash crops and instead seek development through an emphasis on manufacturing.

Yet, manufacturing requires access to technology. At its most basic level, this means access to blue-prints, designs, products, machinery and related 'technology', such as production organisation. Without technology, industrialisation would have been still-born. For instance, without James Watt's steam engine there would have been no industrial revolution,[28] without aircraft and aviation systems there would have been a constrained aviation revolution. From even this cursory review of industrial history, it is apparent that lead sectors may change, dependent upon the industrial epoch and also perhaps the country/regional context. The constant theme, though, is that lead sectors expand and/or improve the efficiency of the production base. Under this definition, the development and production of contemporary airliners are high technology operations and thus, at the heart of the industrialisation process.[29] However, as discussed in chapter 1, aircraft production is arguably the modern-day equivalent of the Industrial Revolution's machine tool sector.

Academics have conceptualised strategic frameworks to understand the development process in the emergence of lead sectors. These technology planning frameworks highlight the centrality of machinery to catapult development to a higher stage. The starting point is the 'western' model, focusing on the evolution of machine tool production in western countries. Professor Nathan Rosenberg, in particular, has written extensively on the contribution that machine tool manufacturers have made, and continue to make, in promoting competitiveness, innovation and the development of a 'machino-facturing' economy.[30]

2.3.1 Western Technology Planning Model

A good reference point for the western model is the world's first industrial revolution, which occurred in Great Britain from around 1760 onwards. Figure 2.2 below, charts the distinguishing characteristics of this model. However, whilst innovation and machinery production were at the heart of the industrial revolution, the origins of the transformation process lie at least one hundred years further back in time. Basic manufactures, such as textiles, were produced without power on simple wooden looms. Workers gathered together in 'factories' and, significantly, all production improvements were undertaken by shop floor operatives. These workers were close to the production process; they could identify innovational opportunities and had the skills to apply. The factories, as such, were vertically integrated, principally because no specialist subcontractors existed during the middle ages. Factory workers, then, had no choice but to engineer process improvements themselves.

As Britain's manufacturing activities expanded, particularly with the onset of the industrial revolution, sufficient demand was created to sponsor the development of subcontractors. Although outputs of the increasingly diverse 1st-tier manufacturers were different, the underlying vertical production processes were the same. This presses,

Figure 2.2: Western Technology Model

Transformation process	Defining characteristics	Development goal
• Consumer sovereignty • One-off/batch production • Technological convergence • Vertical disintegration	• Capitalist • market-driven • Capital-using • Technological innovation	• Profit maximization
Evolutionary process		

Source: author

railway equipment and armaments, all required similar industrial inputs, such as castings, forgings, and of course machine tools to cut and shape metal. As a consequence, sufficient demand was created for the birth of specialist subcontracting networks: ‘make-or-buy’ decision-making or the 18th century equivalent of ‘outsourcing’ thus began to make its debut in Britain. Rosenberg termed this process, vertical disintegration, caused by technological convergence of the underlying vertical processes of production.[31]

Machinery was the lead sector in Britain’s early industrialisation, characterised by a factor endowment of capital abundancy and labour scarcity. Customers would work with machine producers to determine machinery design. This process of consumer sovereignty led inherently to costly one-off or batch production. These production features equated to a capitalist, market-driven approach to engineering development. The search for profit meant that the market was highly competitive providing the basis for technological innovation. However, a major disadvantage of this early ‘Western model’ was that it was capital-using. It was also an evolutionary model, in that it required a considerable elapse of time before a specialist network of subcontractors would evolve. Once this occurred, though, the economy would likely be mature and innovative, possessing a highly diversified manufacturing base.

2.3.2 Soviet Technology Planning Paradigm

The opposite conceptual approach to the western model was the 1930's Soviet technology planning paradigm. As with Britain's earlier industrialisation-push, the Soviet Union designated machine building as a lead sector. The country was a fledgling Communist state. It had effectively a 'closed' economy, with a scarcity of foreign exchange. The Soviet economy was also big, possessing abundant labour, but little capital. These factor conditions obliged Soviet planners to design their initial Five-Year Plans such that rapid industrialisation could be effected without recourse to substantial capital funds.

Machine tool production was targeted as a lead strategic industry. It was believed that planning the development of an indigenous machine tool sector would enable the Soviet Union to capture the following industrial benefits:

- Substantial increases in machinery output from an expansion of the underlying 'means of production'
- Creation of a local production capacity enabling planners the opportunity to design machine tools appropriate to factor conditions
- As machine tool industry represents the 'mother' industry from which all engineering artefacts derive, either directly or indirectly (through second-generation machinery), an efficient machine tool sector allows enhancement of downstream investment opportunities through both lower cost and higher performance machine tool products.[32]

Figure 2.3 shows the key attributes of the Soviet technology planning paradigm.[33] The strategy required planners to direct capital resources to the construction of pre-determined machine tool factories. Particular factories would specialise in the production of only one machine tool type, eg lathes. Different lathe models, reflecting different sizes, could then be produced in just one factory, but, as far as possible, the components and sub-assemblies would be standardardised. This twin focus on specialisation and standardisation allowed economies of scale to be achieved.

Figure 2.3: Soviet Technology Planning Paradigm

Transformation process	Defining characteristics	Development goal
• Producer sovereignty • Specialisation • Standardisation • Scale	• Command Economy • Scientific plan • Technological adaption	• Capital saving
Revolutionary process		

Source: author

The defining characteristics of the Soviet planning paradigm highlights the important role of central planning to guide resources towards what were deemed to be development priorities. Production organisation of the strategically important machine tool producing factories, servicing the entire Soviet economy, was planned so as to exploit opportunities for cost minimisation. Product design represented adapted copies of existing, proven, machine tool products already in production in Western countries, By contrast, the Soviet Union's process technologies were expensive process machines that were imported in limited numbers, solely for installation in the machine tool manufacturing factories. Hence, appropriate (labour-intensive) tool products would be produced in a cost effective (capital-intensive) way, exploiting the opportunities of economies of scale.[34]

The Soviet technology planning paradigm has merit for big countries embarking on industrialisation, like India and China, with abundant labour but limited capital resources.[35] Most importantly, the approach emphasizes capital-saving. However, a major disadvantage for the former Soviet Union was that no market existed, because all resources were allocated by the planning authorities. In a Communist state, with an absence of profit, there is thus no incentive for firms to seek competitive edge. Without competition, there is unlikely to be innovation. The lack of innovation, moreover, will be reinforced by the absence of specialist, innovative, supplier networks. The speed with which the Soviet planners pursued industrialisation meant that there was insufficient time for subcontractors to evolve. Thus, the Soviet technology planning paradigm is a 'revolutionary' model, emphasising scale economies rather than competitiveness and innovation.

2.3.3 African Technology Planning Model

Figure 2.4 depicts a further conceptual framework, this time focused on the planning required to promote African technological capacity. The regional context here is black sub-Saharan Africa, with the Organisation of African Unity (OAU) recognising in 1980 that something urgent was required to initiate economic take-off.[36] The OAU Heads of State agreed on what came to be known as the Monrovia Strategy (after the country where the OAU conference was located), representing a coordinated approach to Africa reducing its dependence on external supply of foreign technology. The Monrovia strategy sought to achieve this goal by developing machinery production as a lead sector. In this respect, machine tools were viewed as the vehicle for the industrialisation-push.

Figure 2.4: African Technology Planning Model

Transformation process	Defining characteristics	Development goal
• Producer sovereignty • Market enlargement • Appropriate Technology • Promotion of Scale • Technology-pull	• Supranational strategy • 'South-South' collaboration	• Economic 'take-off'
Involutionary process		

Source: author

The machine tool output would be appropriate technology, with designs coming from 'South-South' collaboration. Turnkey plants were established in Nigeria (servicing the needs of West Africa) and Tanzania (servicing the needs of East Africa). Through both import tariffs on foreign tools and the promotion of regional African markets, the minimum critical mass of demand for machine tools would be created to justify local machinery production. Over time, demand would 'trickle-down' to encourage the start-up of small and medium size enterprise (SMEs).

Africa's Monrovia strategy was an attempt to transform the economically moribund Sub-Saharan economies through the establishment of designated strategic industries as lead sectors. The strategy emphasised cost reduction through the production of labour-intensive, standard and simple, agri-mechanical machinery. Scale was to be achieved though enlargement of national markets enforced by tariffs imposition on Western machinery imports. This was done via an import substitution policy on a continental scale. The Monrovia Technology Planning Framework was a supranational attempt to push Africa's economies down the runway towards take-off. It was 'involutionary' in the sense that it sought African states to look inwards within the continent for a solution to the technological dependence on foreign technology supply. The model appeared to be working during the early 1980s but its long-term focus on technological self-reliance was overtaken by the short-term needs of survival, as a severe sub-Saharan drought began to bite in 1984. Attention and resources were thus diverted to coping with the effects of the drought, and since that time Africa's technology policy has languished.

2.3.4 Asia's 'Tiger' Technology Planning Model

The final conceptualised technology planning model to be considered has regard to what might be called Asia's 'Tiger' framework. The Tiger metaphor was originally applied to the small Asian states of Hong Kong, South Korea, Taiwan and Singapore, all of which developed modern, high-growth, economies through the 1960-80s. Moreover, from the latter part of this period, the People's Republic of China could legitimately be added to this list.[37]

As illustrated in Figure 2.5, the Tiger economies planned a rapid economic transformation through the adoption of a 'hybridisation' approach to industrial and technological development. Essentially, these Tiger economies abstracted appropriate elements of the Western and Soviet technology models, adapting them to a planning approach appropriate to the economic circumstances faced by the post-WWII newly emerging Asian States. Scale was sought through aggressive export promotion. Long production runs allowed unit cost reductions to be achieved. Price-driven competitiveness in export markets was combined with parallel improvements in product quality. Innovation imperatives were fostered at both the corporate and governmental levels; the latter reflected the fact that government in all the ‘Tiger’ states was, and continues to be, interventionist, providing institutional support for R&D as well as incentives for the protection and promotion of designated ‘infant’ industries.

In the development of lead sectors, Asia’s ‘Tiger’ technology planning model emphasised the promotion of strategic industries producing critical technologies.

Figure 2.5: Asia’s ‘Tiger’ Technology Planning Model

Transformation process	Defining characteristics	Development goal
• Scale • FDI-led development • Export biased • Technology-pull and -push	• Corporate and government strategy • Technological innovation, not invention • Role of foreign investment	• Indigenous industrialisation
Hybrid process		

Source: author

However, an important distinguishing characteristic of this model, compared to those described earlier was, and is, the heavy reliance on FDI in the pursuit of self-sufficiency. Given the small size of their economies, achievement of this latter policy-goal for most of the Tiger states was probably beyond their reach. Self-sufficiency nevertheless remains a cultural and institutional policy tenant. For China, in particular, self-sufficiency, reflected in the drive towards indigenous industrialisation, is not only a policy ambition, but unlike the other Tiger states, is also probably achievable. For China, FDI was the principal vehicle for inward transfer of the enabling technologies required for economic transformation. As with most other latecomers to industrialisation the planning goal is non-dependent industrial and technological development; that is, indigenous industrialisation.

2.4 Technology Development through 'Strategic' Industrialisation

Technology development is the third phase of the cycle towards achieving self-sustaining industrial and technological take-off. It represents the practical culmination of the earlier planning phases, contextualising development according to the growing maturity and diversity of the local manufacturing base. The technology development phase focuses on the promotion of 'champion', 'backbone' or 'strategic' industries in the 'latecomer' industrialising economies, such as Malaysia, South Korea and China. Technology development is the final phase towards indigenisation of production activity; the closing stage of technology transition. Planning for technology acquisition is a fundamental part of the industrialisation process. Why 'reinvent the wheel' when technology can be transferred from the advanced economies.

Technology transfer can be defined as the diffusion and adaptation of new technology, equipment, practices and know-how.[38] This definition of technology transfer seems straight forward, but the process is complicated. Successful technology transfer needs attention to the following aspects of affordability, accessibility, sustainability, relevance and acceptability.[39] Multinational Companies (MNCs), in particular, have a number of options for technology transfer. These include contractual arrangements, such as technology licensing agreements, joint ventures, technical assistance, turnkey projects and direct foreign investment in wholly-owned subsidiaries or affiliates. Transfers also occur, for example, through the education of students abroad and through trade in capital goods between unrelated parties. Technology transfer can be understood as the process by which technology moves from one physical or geographical location to another for the purposes of application towards an end product.[40] Transfer can take place either domestically from one sector to another or from one country to another conveying the required knowledge, experiences and skills.

Technology transfer may comprise some or all of the following: fabricated materials and capital goods such as machines, instruments, equipment and associated technology (including as design and execution works); preparation of feasibility studies for projects, including technological experience; and skills, comprising knowledge relating to production, patents, documents, drawings, operation programmes, maintenance instructions, training and education activities.[41] Figure 2.6 identifies technology transfer as a 'progressive' process. A technology, chosen, installed and operated by others not performing an active role in such operations, may nevertheless involve technology transfer via the transfer of:

- Capital goods and engineering management and administrative services
- Operation and maintenance skills
- Technological knowledge and experience to acquire new and productive capabilities through local manpower acquiring the knowledge and ability to produce ongoing technological change.[42]

Figure 2.6: Development Stages in Technology Transfer

Stage 1	Stage 2	Stage 3	Stage 4
Equipment Import from Advanced Countries	Inward Technology Transfer via JVs or FDI	Indigenous Industrialization through Promotion of a Local Supply Base	Outward Transfer of Techology

Source: Abdulrahman Al Ankari, *Technology Transfer: a Case Study Analysis of the Saudi Oil and Petrochemical Sectors*. Cranfield University (2004), PhD thesis

The two principal motives for a country to promote inward technology transfer are the creation of:

Investment capacity: the capacity to establish new production units and to expand existing ones

Innovation capacity: the ability to develop new techniques to achieve certain objectives.

However, the importation of technology does not lead automatically to local technological development. For this to happen, local workers must take part in the process by trying to understand the technology, identify how it works and adapt the scientific and practical methods associated with its uses. Thus local firms must be able to improve productivity and adapt the technology to the changing conditions. Gill Wilkins, for example, notes that technology transfer should assist local workers in developing the skills to choose appropriate technology, adapting the technology to local conditions and service requirements, and integrating it with existing indigenous technology.[43]

Productive capacity influences investment and innovation capacity. For example, production engineers might acquire engineering manufacturing experience. In addition, they might also acquire the ability to adapt the technology through knowledge gained in the maintenance of machinery and the resolution of production bottlenecks. However, this capability is usually not enough to acquire the ability to design new production units or invent new technology. Such experience is acquired in specialised scientific and technological institutions and machinery and equipment plants. Moreover, the expansion of local productive capacity in a particular field will lead to the development of other sectors and industries, possibly resulting in the establishment of specialised institutions for the transfer and development of technology.

Technology can be transferred through international organisations between two or more countries. Transfer can be performed in a commercial or non-commercial exchange between the private and public sectors. The channels include licensing, direct foreign investment, commodity reciprocity and strategic alliances. Likewise, technology transfer can be performed within the company or through mutual transfers between companies and government. Transfer mechanisms are diverse due to the fact that technology is not merchandise to be sold and purchased in the market. Technology comprises a mixture of material and conceptual elements that cannot be separated. Several mechanisms exist for transferring technology, namely:

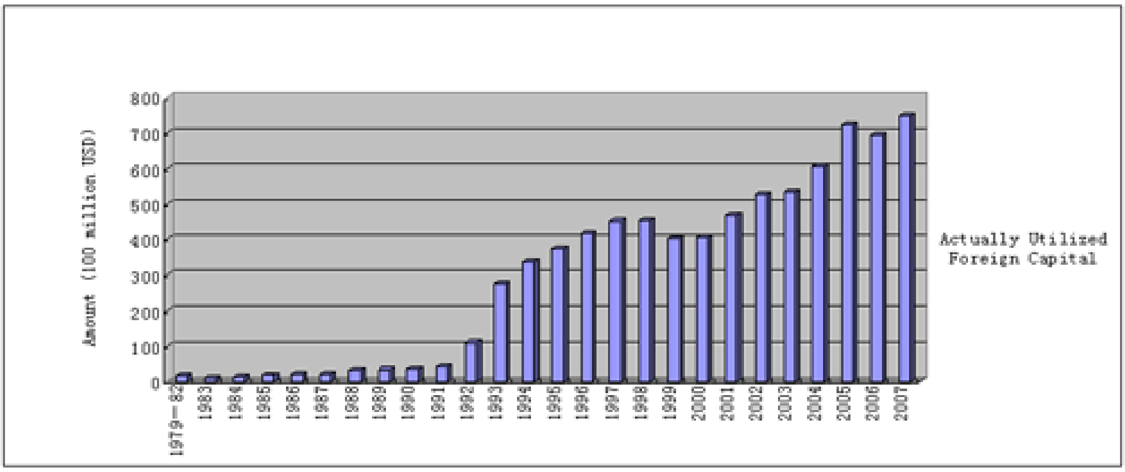
- Foreign investment
- Technical cooperation agreements
- Economic offset programmes
- Licensing agreements
- International subcontracting
- Joint ventures
- Research and development cooperation.[44]

According to Jose de Cubas, the foreign investment package, in most circumstances, is the most effective and cheapest way for technology to be transferred.[45] Foreign investment, by definition, implies ownership of capital by the foreign firm and the power to exercise control over operations of the entity in which such investment takes place. It is different from portfolio investment, as the latter involves only the acquisition of foreign securities by individuals or institutions without any control over, or participation in, management of the companies concerned. The most clear-cut case of foreign investment occurs when a firm sets up wholly-owned subsidiaries or affiliates abroad, where the operating control and usually the majority ownership of capital rests in the hands of the foreign firm. These subsidiaries may be established by the take-over of existing local firms or they may take the form of new green field ventures. These subsidiaries need not be wholly foreign-owned. Foreign direct investment may involve a joint venture agreement where a foreign-based firm has a majority share, an equal share, or even a minority share, in the ownership of the enterprise abroad. The important defining requirement of FDI, though, as noted earlier, is that the foreign company has operating control.

2.4.1 FDI: Vehicle for Technology Transfer

Due to increased international recognition of the benefits of free trade and capital mobility, not least because of expanded WTO membership, FDI has accelerated in recent years. In China, for instance, FDI surged from US$5.5 billion in 1990 to 74.8 billion in 2007 (see Figure 2.7).[46] MNCs are the dominant source of FDI and hence the principal vehicle for technology transfer. The growing size and power of MNCs means that they dominate world trade: the annual sales of the six biggest MNCs are only exceeded by the GDP of 21 states; MNC total sales amounts to two-thirds of global trade; and, remarkably, around 40 percent of world trade occurs ‘within’ MNCs.[47] One way of viewing a multinational enterprise is as an economic institution that owns (in whole or in part), controls and manages income-generating assets in more than one country. In doing so, it engages in international production as a by-product of the imperfections in goods and factor markets across the globe. In a perfect market, no advantages can accrue to the MNC enterprises. However, in reality, MNCs possess some advantages enabling them to produce and compete successfully in an unfamiliar

Figure 2.7: China's Total Actually Utilized Foreign Capital in the Past Three-Decades



Source: 'Invest in China' downloaded from http://www.fdi.gov.cn/pub/FDI_EN/News/Focus/Subject/wzzgxe/wzfzjj/t20081204_99879.htm (19, April, 2009)

foreign environment. Theorists,[48] have suggested numerous ownership-specific advantages[49] deriving from possession of technology and marketing skills, as well as location-specific factors[50] like trade barriers and host government policies. Several authors have noted the different kinds of enterprises and associated forms of foreign investment.[51] For example, Caves[52] grouped foreign investment into the following categories:

- **Horizontally integrated enterprises:** these are multi-plant firms that have established plants in different countries to produce the same or similar goods. Teece noted that the horizontal kind of investment directed at producing goods and services abroad, constitutes a significant portion of the world's stock of investment.[53] Horizontal enterprises internalise markets for intangible assets (covering the knowledge that represents new products, processes, proprietary technology and the like). The reasons behind such investments may include the possession of an intangible asset such as technology, which the multinational firm can extract maximum rent through foreign production rather than licensing technology to a foreign producer.
- **Vertically integrated enterprises:** These are international multi-plant enterprises, producing outputs in some plants and supplying inputs to other

plants. By comparison to best practise, MNCs operating in developing country environments may be obliged to pursue vertical integration as an efficient method of achieving supply reliability of intermediate products.

The effectiveness of FDI as a mechanism for technology transfer and by implication, its role in the development process, has long attracted attention. For instance, Lewis and Caves have argued that the benefits of FDI include the generation of exports and foreign exchange, tax revenues, employment, accumulated capital and entrepreneurial skills.[54] Transferred technology can also provide wider benefits to the recipient countries. The OECD endorses the positive view of the role that FDI can play in economic development.[55]Supporting this view, the UNCTAD secretariat estimates that from 1991-1996, only 27 of almost 600 changes in host country FDI policies were in the direction of greater restrictiveness.[56] Exposure to a more open domestic market resulting from FDI is a source of competitive strength and exposure to international trade is a powerful stimulus to efficiency.[57] Moreover, the market power of MNCs allows them to overcome many of the economic obstacles associated with government. For instance, it is argued that MNCs enjoy benefits from the lack of bureaucracy, the ability to bypass protocol, the need to accelerate decision-making processes and, overall, a more comprehensive access to global markets and supply networks.[58]

FDI provides numerous economic benefits to the recipient economy, but as Table 2.1 shows, there are also negatives associated with foreign investment. There have long been criticisms of MNCs, in the way that they allegedly exploit the workers of recipient

Table 2.1: FDI Cost-Benefit Analysis from the Recipient-Country Perspective

FDI Benefits	FDI Costs
• Acquisition of jobs and engineering, management, marketing and R&D skills [59] • Creation of local supplier capacity, including jobs and skills • Improvement of operational efficiency • Potential for technology spill-overs, including skill and	• Suppression of local supply [64] • Increased dependence on foreign companies (loss of national sovereignty) • Exploitation of labour through continuance of low wage payment • Government inducements and incentives to persuade MNCs to locate[65]

innovation transfer [60] • Source of scarce capital • Capture of new local and foreign markets • Long production runs combined with low unit cost through scale[61] • Exploitation of local natural resources • Development of domestic infrastructure • Creation of advanced logistical networks[62] • Contribution to balance of payments surpluses through both export promotion and import substitution • Evolvement of dynamic comparative advantages • Knowledge transfer • Nurturing of ‘synergistic’ technology clusters[63] • Reduction of bureaucratic obstacles	• Dominant impact of MNCs on the local economy[66] • Cultural problems in JV FDI[67] • Potential inflationary effects • Low value added production (assembly operations) • Weak promotion of local supply chains • Dependence on foreign- sourced management and R&D • Limited design capability • Transfer price problem, particularly loss of local tax revenue[68] • FDI creates jobs, but perhaps not the right jobs • Negative environmental impacts[69] • Potential to suppress trade union representation

Source: author

economies, by paying low wages, with limited provision for social overhead capital.[70] Production concentrates on low value-added activities, local sub-contracting activity is suppressed and cultural clashes are endemic as MNCs impose their corporate practices on an alien local business environment.[71] At the macro-level, the recipient economy faces the potential danger of losing corporation tax revenue through MNC transfer pricing policies, with the likelihood that low interest rates to attract FDI will lead to inflation.[72] Indeed, Stiglitz argues that whilst low interest rates in the recipient economy may attract FDI, leading to higher growth, ultimately, local development may be restricted through what he terms the ‘Dutch Disease’.[73] This refers to the Dutch experience of natural gas finds in the North Sea, leading to increased demand and the strengthening of the Gilder, with exports becoming increasingly uncompetitive.[74]

A major policy question surrounding FDI is whether or not it actually promotes the transfer of technology, capital, and management to the host country? This question turns on the effect of firm-entry on technological capabilities. Even if enterprises transfer the best production technology, they do not necessarily transfer the capability to generate future technology. In some cases, they transfer 'know-how' (production engineering) but not 'know-why' (basic design, research and development). Local companies that are subsidiaries of foreign companies depend on the flow of technology as developed by the central organisation's research and development activities. Research and development activities performed by the subsidiary companies are often extremely limited, if not absent.[75] Local Research and development provision reflects limited adaptation of products to suit domestic conditions, often only including supply, maintenance and training.[76]

2.4.2 Seven Stages of Technology Development

A widely used development model for explaining the Tiger States path towards industrial and technological development is the 'flying geese' model. The analogy of the flight pattern of geese reflects the fact that Asian states, as late-comers to industrialisation, defer to Japan as the region's technological leader. The process is thus one of a 'path' of Asian countries following and always trying to catch-up with the technologically dynamic Japan. The economic rise and fall of states is seen as a process that is tightly linked to the emergence, maturation and decline of particular industrial sectors. The 'Flying Geese' model posits that the diffusion of new products and technologies begins with their import into the less industrialised countries. Capital goods imports follow, and global 'homogenous' industries are established. In the final phase, the industrialising countries develop their own capital goods industries and an export capability is created.

Table 2.2, below, shows the seven principal stages of technology transition within the 'Flying Geese' model that industrialising countries need to pass through.[77] The seven technological stages are sequential, with competence rising as countries progress towards stage seven. Technological leap-frogging, across previous stages is feasible, but from stage five onwards, the degree of difficulty in achieving industrial capability, increases the higher the stage reached. China, for instance, has implemented development policy to promote oil and petrol-chemical industries, telecommunications, automobiles, sophisticated microelectronic chips, advanced electronic industries, as well as the development of an incipient commercial aircraft industry. Notably, these strategic sectors are referred to as 'dual-use' industries, their products having application to both

Table 2.2: Seven Stages of Technology Transition from the Recipient-Country Perspective

Stage	Technological Level	Product Type
1	Light industry at most, low capital	Raw materials, handicrafts
2	Assembly and processing	Toys, clothes
3	Expand to heavy industry, consumer electronics	Televisions, assembled CD players
4	Increase local content, employ more technology-intensive processes, invest in brand name development	Indigenously branded electronics with local content
5	Top-shelf electronics, export of capital intensive goods	Chemicals, autos, high-end electronics
6	Domestic market drives growth, world leader in high-tech production (though not innovation)	Korean DRAMs
7	Innovator at the technology frontier	Long-haul commercial aircraft, advanced pharmaceuticals

Source: Nina Hachigian and Lily Wu, *The Information Revolution in Asia* (RAND, 2003), page 24; modified by Daniel H. Rosen. See http://www.rand.org/publications/MR/MR1719/

Note: China is arguably located between stages 4 and 5, but categorisation will vary from industry to industry.

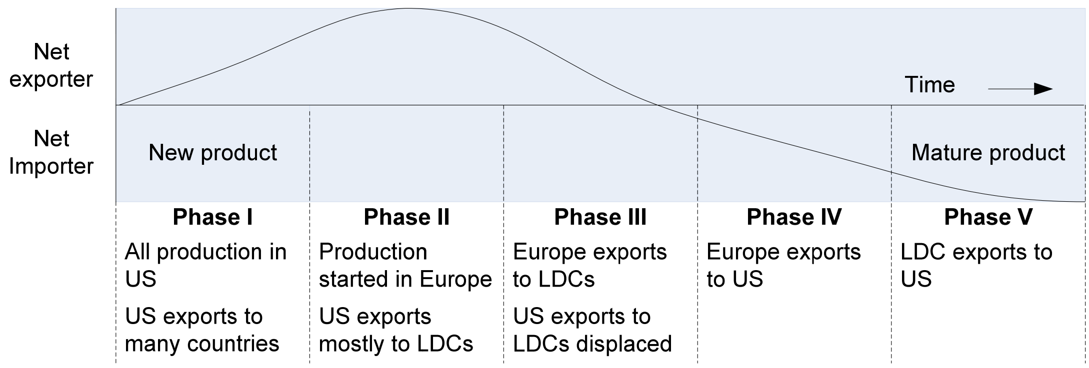
civil and military production. They are industries, therefore, that can be truly described as lead sectors, located at the technological frontier of their respective fields of activity.

The Flying Geese model is principally concerned with the role of leading sectors, viewing them as determining the development of national economies. This emphasis on the leading sectors thesis has also been linked to Raymond Vernon's 1960's International Product Life Cycle model, see Figure 2.8.[78] Vernon postulated that product innovation occurs in high-income countries, such as the US, but diffuses over time to the poorer countries. As the product and process technologies mature so production cost, particularly labour cost, becomes more important. Vernon argued that ultimately the Western firm that originated the product innovation abandons production as its oligopolistic advantages disappear. The advanced firm willingly dispenses with output because it has cultivated a more advanced replacement product, thus maintaining the technology-gap between itself and competitor firms in the industrialising world. Vernon's theory predicts that in the final stage of the international product life-cycle the originating firm/country will exit the market, ceasing supply of this 'old' technology. However, there is a debate as to whether this actually happens, especially with respect to the knowledge-intensive products of leading 'strategic' sectors.[79] The objective of closing the 'technology gap', particularly for newly emerging countries, such as China, thus becomes more challenging.

A constant in the development of all these hi-tech industries is the dependence on FDI. Foreign capital and expertise are now viewed by policy-makers as a positive influence, providing an inexpensive access to modern technology propelling the local economy forwards on a steep Rostow-type 'flight-path' of self-sustaining economic growth.

FDI can act as catalyst for indigenous industrialisation, but there are two sets of players in the development process, both with differing motives. The first player, the MNC,

Figure 2.8: The Product Life-Cycle As An Evolutionary Sequence of MNC Development



Source: P.Dicken, Global Shift - *Mapping the Changing Contours of the World Economy*, Sage (2008) p 114 ,

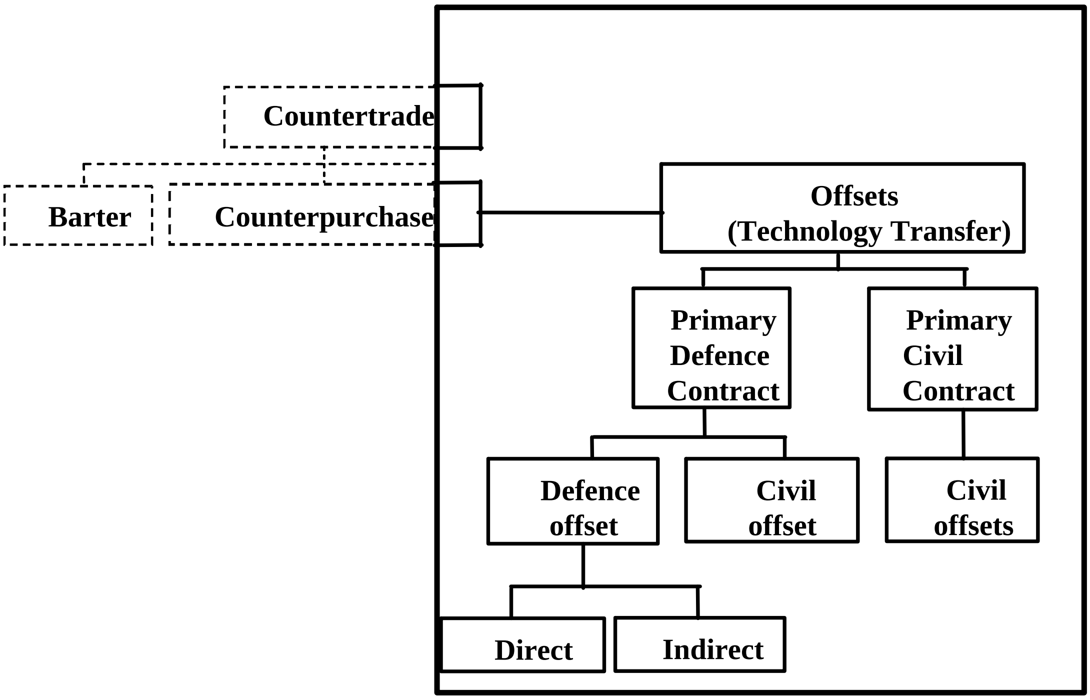
locates close to a growing market, with the intent to exploit low cost labour positions for growing regional/global growth, maintaining organisational control, limiting technology access, minimising tax payment and maximising profit potential. By contrast, the second player, the host economy government, is impatient for the broadening and deepening of technology transfer, the generation of highly skilled labour, increased tax revenues, and progressively higher added value investment into the local economy.

2.4.3 Offsets as a Form of Technology Transfer

The above review of the role that FDI has played in the 'planned' technological transformation of China has relevance to all industrial sectors. However, of particular relevance to defence and aviation is an important vehicle for technology transfer known as offsets. Whilst offsets apply principally to defence and military aviation, it is, as will become evident, of increasing significance to commercial aviation development, also.

As shown in Figure 2.9, offsets represent one aspect of what is referred to as countertrade. In broad terms, countertrade is concerned with reciprocal trading activities that are often characterised by non-monetarised transactions barrier is the most obvious form of countertrading activity. Simple barter refers to one-off transaction, where money does not change hands. This is not that common in the 21st century, rather it is

Figure 2.9: The Evolving Offset Typology



Source: Matthews, R, 'Saudi Arabia: Defense Offsets and Development', (eds) Brauer, J ard Dunne, l, *Arming the South*, Palgvave (2002) the slightly more complicated ‘clearing arrangement’ which has found favour amongst defence and aviation companies. Here, for instance, shipments of oil will be credited against the liabilities incurred for the purchases of multi-billion dollar arms purchases; this reflecting the payment system in the British-Saudi Al Yamamah 1988 arms deal. Other examples include the Iraqi purchase of Soviet MIG fighters and T-72 main battle tanks. The third form of barter is described as switch-trading or ‘swaps’. This exchange of money for goods, focuses instead on the need, often, for multiple swaps of goods by independent buyers and sellers, in order to finally close an initial deal and secure a mutual exchange of wants. A simple swap transaction might involve selling, for instance, Rolls-Royce aero-engines to Russia, with payment being made through the transfer of credits (via Indian goods) that Russian enjoys with India. Russian payment to Rolls-Royce is conducted by ‘swapping’ India’s trade debits with Russia to Rolls-Royce, UK, with the payment in the form of Indian goods not cash.

The second major form of countertrade is called counterpurchase. This differs from barter, because here, money does form part of the overall transaction. An illustration of a typical counterpuchase deal relates to Malaysia’s purchase of British Hawk trainer/fighters in the late 1980s. There were two contracts: The first was the primary aerospace deal in which Malaysia procured 28 Hawk aircraft, paying for these in hard currency; the second, linked, contract had regard to the counterpurchase deal, with Malaysia demanding that BAEs (counter) purchase local palm oil and rubber to the value of 60 per cent of the primary Hawk aircraft contract price.

Both of the above countertrade deals (barter and counterpurchase) offer short-term economic multiplier benefits through the creation of demand in the local market. However neither involves technology transfer; this latter aspect is fundamental, however, in the final form of countertrade arrangement, termed offsets. Whilst barter and counterpurchase are the preserve of the poorer countries seeking to stimulate demand for commodities in the local market. Offsets, by contrast, centre on the advantages associated with long-term technology transfer. The technologies transferred are normally targeted at providing the process capacity for producing defence and/or commercial technologies. Offsets are sometimes described as a ‘win-win’ situation in which both parties to the contract benefit: the advanced country contractor gets to make the sale in a tight international market, and the poor country seeks to exploit its market power and leverage from the deal by obtaining technology transfer. The latter can be either direct (relating directly to the primary defence/aerospace contract) or indirect (relating to typically civil investment) unassociated with the primary defence/aerospace deal.

Over the last 20 years traditional offsets model has expanded to reflect a number of market developments (as depicted in Figure 2.9). On the defence side, defence offsets are now sub-divided into direct offsets (linked to the primary defence contract) and indirect offsets (tied to other defence programmes unrelated to the primary defence contract). Also, there are indirect offsets, and these have regard to foreign defence contractors, after concluding on arms deal, being obligated to investing in commercial projects, independent of the primary defence contract. An example of indirect offsets would be the case of be Tate & Lyle, encouraged by BAEs (UK prime contractor under the AL Yamamah arms deal) to build a sugar refining factory.

The important development in offset activities, of relevance to the present study, is the emergence of what might be termed civil-civil offsets. This is a recent innovative form of reciprocal trading mechanism, applying to central and local government procurement contracts. The contracts must be above a stipulated value to trigger a demand for offsetting investment by the overseas vendor company. World Trade Organisation regulations demand that developing countries, so defined, can engage in civil-civil offsets, but not advanced states. Moreover, such contracts are normally mega-dollar procurements, hence relevant to the purchase of expensive projects, such as power-generating stations, oil refineries, and significantly commercial aircraft in oligopolistic international markets.

Commercial aircraft are ‘big ticket’ items. Consequently, a country/company procuring modern aircraft for its national airline is in a strong position in a competitive global market to demand compensatory investment. This would most likely come in the form of work packages, including maintenance, repair and overhaul contracts, R&D, and in the extreme, complete licensed production of the entire aircraft. China, in the development of its commercial aviation industry, has benefited from such civil-civil offset-related technology transfer. This has occurred where regional airlines, including Southern Airlines, Eastern Airlines and Xiamen Airlines, have procured Boeing or Airbus passenger aircraft. Work would then flow back into China's aircraft factories (AVIC I and II), tied to, for example, the production of vertical and horizontal tail-fins and simple fabrication of structures on the main wing assemblies. Civil-civil offsets also encompass higher-level technology transfer programmes, including Embraer's license production of the ERJ-90 at Harbin and the very big programme at Tianjian involving the license production of the Airbus A320.

In recent years, a number of developing countries have engaged in technology offset contracts. In the early 1990s, for example, Saudi Arabia demanded civil offset work on the US$6 billion procurement of Boeing commercial aircraft for the national carrier, Saudi Airlines. This offset deal led to civil work on Boeing commercial airliners being channelled into the offset companies that were established under the Saudi Al Yamamah military offset contract. Similarly, the Indonesia Government sought civil technology offsets when purchasing Boeing passenger aircraft for its national airline, Garuda. The offset work went to Bandung–based aerospace company, PT IPTN (now called PT Dirgantara). Here, components and sub-assemblies would be produced under strict quality standards for onward delivery to Mitsubishi factories in Japan. The Japanese company would then integrate PT IPTN's technologies into its own sub-contracted sub-assembly work for final delivery to the Boeing factory in Seattle, US. In this way, technology offsets can be seen as a truly global subcontracting network of manufacturing activities.

2.4.4 Offsets: Moving from Policy to Practice

Technology transfer though licensed production is the most common form of offset. The aim is to leverage high technology from advanced country suppliers to establish local manufacturing capability. To facilitate this process mostly all countries have in place offset guidelines or policies. These provide the regulatory framework against which foreign vendors construct offset programmes. The guidelines, are, by definition, prescriptive, but often there will be flexibility in their application. But this will vary from country to country. The UK's Industrial Participation Policy,[80] in other words offsets is based on a voluntary code, and is not the usual approach. Even more extreme, however, are the few countries that possess no formal offsets guidelines. These countries include Japan, Singapore and China. Under such circumstances, offset deals are worked out by the local government procurement agency and the foreign contractor; they will be negotiated, with the final outcome based on the relative bargaining strengths of the two contracting parties.

Whilst the overseas vendor will seek to minimise the percentage offset requirement, the host country (purchaser) of the defence/aerospace system will aim to achieve the highest percentage technology transfer package. The goals of the offset package will normally highlight some or all the following considerations: maximisation of local job opportunities, increased skill content of local workers; economic diversification; promotion of high technology production; development of MRO services; and the introduction of higher value-added operations, including systems integration and R&D. The development of strategic, long-term, mutually beneficial offset relationships depends on the foreign contractor agreeing to progressively transfer acceptable levels of technology. Clearly, though, it is not in the transferor's/commercial interests to release large amounts of modern technology to the transferee's country, giving that this intellectual expertise/knowledge will likely have taken decades to accumulate. Thus, the final offsets package is the outcome of the relative bargaining strengths of the two contractual parties.

2.4.5 Effectiveness of Technology Offsets.

Recipient countries seek to manage offsetting investment to secure as much economic advantage as possible. However, there is much complexity associated with efficient and effective implementation of offset programmes. Should they be obligatory or voluntary? Should the offsets be directed towards direct (often defence) investment or indirect (social and commercial) objectives. What is the appropriate percentage offset target? Should it be modestly set, say 30 percent of the primary contract value, and therefore more attainable by the foreign vendor, or should it be targeted at 100 percent of the primary contract value to achieve as much technology transfer as possible? Should multipliers be applied to certain sectors, such as education and training? Thus, offsets investment targeted at, say, education, attracts a multiplied credit of 5:1; instead of 1:1 to be set against the vendors' total offset target value. Finally if vendors fail to achieve the required total offset value in the contractually specified future period should a penalty be imposed?

These, and numerous often policy issues, need to be addressed by the country offset committee. Notwithstanding this requirement, however, there is still much dissatisfaction over the effectiveness of offsets to deliver on the pre-determined development objective. The regular complaint is that insufficient technology transfer is achieved; that the capacity transplanted into the recipient country represents assembly, not production, of basic parts and components. The high value-added work is not transferred, remaining in the vendor's factories in the advanced economics. It is also argued that 'any' jobs created are labour-intensive rather than capital-intensive, involving minimal skill enhancement and limited export potential, Moreover, export possibilities are weak because the vendor tightly controls the export of proprietory knowledge to third countries. However, perhaps the most significant negative feature of inward technology transfer through offsets is the difficulty of ensuring the sustainability of manufacturing programmes. A problem here is that scales of production for most of the economies in the developing would are limited. This, in return, has the commercial drawback of reducing the offsets beneficiary's competitiveness. Due to the limitations of scale most country recipients of offsets have focused on the development of MRO capability. This is an economically rational approach in that it provides a service that will be typically demanded over the lifecycle of the defence/aerospace system procured.

There are many other considerations that work against the long-term effectiveness of the offsets package, but there is a need to evolve design capacity to refresh or replace product and process technologies transferred. Design and innovational skills do not normally reside in the prime contractor, which focuses on the development of systems integration skills combined with corporate policies aimed at cost reduction through scale. Innovation, by contrast, tends to come from value chain activities. The possession of strong and competitive supply chains is not a characteristic of developing countries. Offsets, at least in the short-run, are unlikely to stimulate local subcontractors, without informed and well-directed government policies. Most of the offset programmes analysed in this study show little evidence of supply chain creation.

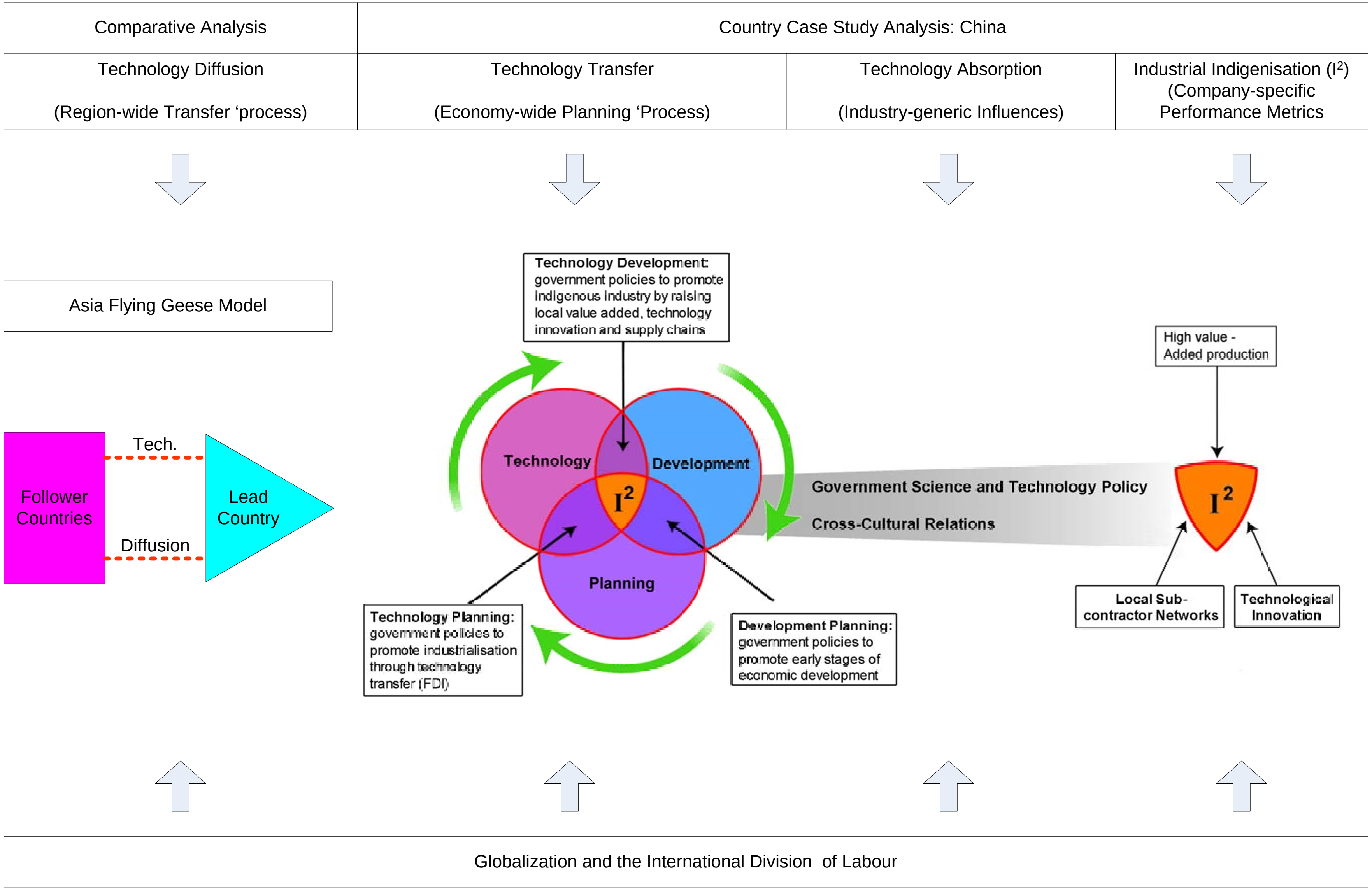
Offsets are a sensitive field of study for defence/aerospace contractors because they form part of their marketing strategies. Hence empirical studies that examine the impact of offsets on sectoral development in recipient countries are scarce. However, there are two major offset programmes that have attracted much academic alternation. The first has regard to Saudi Arabia's offset experience in the 1980s and 1990s and the findings indicate that little of the offsets development objectives were met. In particular, the Saudi goal of creating 75,000 skilled workers from the Kingdom's three substantial offset programmes was not fulfilled, with just a few hundred Saudi unskilled jobs being created across the agreed period of time.[81] The second example relates to the South African offsets programme introduced in the early 2000s. Here, the South African offset authorities had planned to create around 67,000 jobs for black people from the defence and civil offsets work and technology transfer packages.[82] Although there exist contradictory evidence on the effectiveness of this offset package, it is reasonable to conclude that the job creation and sustainability objectives have not been achieved.

For offsets to work, it seems likely that the recipient country must possess the absorptive capability to adopt and develop the technologies transferred. The absorptive capability will be located in the local sub contractor supply chains, in the university and R&D institutes, in the advanced skill-sets of the workers, and, more generally, in the scientific and technological base of the technology receiving economy. Thus, offsets might work in Japan, the UK and Singapore, but there will be serious questions over their effectiveness in the poorer countries. The research question for this study is whether offsets will work in China, specifically in the context of developing a sustainable indigenous Chinese commercial aviation industry.

2.5 Enter the 'Dragon': The Technology Absorption-Indigenisation Challenge

In contemporary Asia, the 'Tiger' technology development strategy has enjoyed substantial empirical investigation. By comparison, China's 'Dragon' technology model, emphasizing the promotion of pillar industries, has received scant attention. The purpose of this study is to address this research lacuna by evaluating the effectiveness of China's technology strategy through empirical analysis of one of the country's principal lead or strategic industries, aviation. The analytical framework adopted is shown at Figure 2.10, overleaf, representing an extended version of Figure 1.2. The confluence of the three circles in the Figure 1.2 venn diagram represents indigenous industrialisation (I^2) and is the goal or outcome of the development planning, technology planning and technology development phases of the cycle. Figure 2.10 develops the venn diagram identifying and justifying the critical attributes characterising the establishment of domestic industrial capabilities. In order to sustain this capability, however, it is essential that local industries are able to infuse and hence develop the technologies transferred through FDI and offsets. Effective absorption of transplanted technology will depend on an array of variables, but critical amongst these will be supportive government policy as well the capability of local organisations to culturally assimilate the technologies transferred. Whatever the preferred development and technology. strategy, the barriers to technology transfer will inevitably remain high. Indeed, with the passage of time, late-comers to industrialisation will increasingly find the technology-gap between themselves and the advanced nations ever widening. The challenge to overcome the rich countries' dominance of global intellectual capital has incentivised the industrialising world to 'indigenise' technological capability. For developing countries industrial indigenisation is an ambitious goal. Progress towards its achievement is shown at Figure 2.10 as the final goal of the technology transfer 'pathway'. I^2 performance can be measured by evaluating: the degree of value-added generated locally; the success or otherwise in promoting domestic innovational capacity; and the extent to which higher quality local skills have been generated. These metrics will be employed in Chapter 5 to measure empirically the progress sustained by China's aviation industry in achieving industrial indigenisation. Industrial and technological

Figure 2.10: Aviation Production in China: The Technology Transfer-Absorption Pathway to Indigenous Industrialisation I^2



Source: author

self-reliance is still the policy goal of Beijing. However, in the present rapidly globalising international economy, simultaneous achievement of sovereignty and sustainability is probably a contradiction in terms

2.6 Technological Absorption

There is a panoply of factors influencing the success of the technology absorption process, including economic, political, social and technological. Most of the issues will be captured during company-level analysis, particularly… "transaction costs involving the revenue-enhancing and cost-reducing opportunities… [that]…are primary considerations both in the decision making of FDI and offsets and in the selection of entry models."[83] Of the major influencing variables at the industry-level, arguably two of the most important are, firstly, an 'interventionist' government approach encouraging the development of a domestic science and technology infrastructure and, secondly, the challenge of assimilating the divergent business cultures of China and other countries. The cultural gap between, especially, East and West, is created by societal differences in work attitudes, motivational structures, interpersonal norms and negotiation patterns that cannot be eliminated in a short time.[84]

2.6.1 Government Sponsorship: the 'Visible' Hand of Resource Allocation

In his 1990 book *The Competitive Advantage of Nations*,[85] Michael Porter developed what he termed the Diamond model to explain the economic success of various countries. One of the points of the 'Diamond' is strategy and one of the important contextual conditioning factors of the model is the supportive role that government can play in promoting economic development. Since the publication of Porter's book, it has become widely recognised that government intervention in support of industrial and technological development is *derigour* for rapid progression towards I^2. Equally, Porter highlights the important role played by corporate strategy; the need for businesses to identify their goals as well as the strategies required for achieving them. Combined, government and corporate strategy, particularly in the science and technology area, can make an important contribution to corporate and country development performance.

The aviation industry questionnaire (Appendix 1) focuses on corporate and government policies designed to enhance the development of corporate technological capabilities, including R&D investment, cooperative research, product development, and infrastructural investment. At the industry-level, it is now axiomatic for government to adopt an 'interventionist' approach, promoting an appropriate science and technology strategy to create local innovative capability. Innovation demonstrates the capacity of a country to go beyond the threshold of dependence on overseas technology suppliers and progress towards self-reliant indigenous development. This process need not take generations to work through. Technology transfer and there to its effective absorption, can be facilitated, indeed, accelerated through government patronage. Particularly in Asia, governments take a long-term strategic view of economic development. They build for the future by investing in both physical and human capital infrastructures. Governments in Asia have invariably employed a science and technology strategy that highlights and promotes government-industry-university trilateral partnerships, technology education and training, R&D funding in critical technologies fields, industrial clustering - both horizontally and vertically between manufacturers and subcontractors, and specialized niches of industrial excellence in high technology fields.[86] In parallel, incentivisation programmes have been introduced to attract foreign companies to relocate manufacturing and R&D capacity. Incentives might include tax concessions, low interest loans and the financial sponsorship of world class R&D laboratories.[87]

2.6.2 Cross-Cultural Relations

Overseas business ventures involve considerable risks, including costly delays from bloated bureaucracy, political instability, exchange rate volatility, and war. However, arguably one of the biggest risks MNCs face derives from cultural barriers.[88] China, in particular, has proven to be a battle zone for foreign companies that have grappled, often unsuccessfully, with the complexities of local business culture. At the root of China's cultural values are *Guanxi* and Confucianism.(*Rujia Sixiang* 儒家思想). These two values represent important influences, having the power to either advance or retard China's present dynamic growth and development performance, depending on how they are managed by both foreign and local stakeholders.

Guanxi reflects China's emphasis on the cultural attributes of interpersonal and inter-organisational relationships and networking dynamics. The *Guanxi* concept comprises four important components:

- the role of intermediaries (social connections providing leverage in the transferability of g*uanxi* and also trust in business associations with unknown parties)
- *Mian zi* (in Chinese business culture, reputation and social standing rests on the intangible social currency of both saving and creating 'face')
- Reciprocality (a network of reciprocal bonds where the refusal to return a 'favour' will cause loss of face, creating a lack of trust)
- Corruption (not an element of *guanxi*, but sometimes required when *guanxi* does not exist and 'deals' are needed to oil the wheels of an inefficient, bureaucratic Communist regime).[89]

Confucianism is a social philosophy in which the principal concern is the establishment of social harmony in a complex society characterized by an orderly hierarchy. Confucianism is not a religion but a set of pragmatic rules for daily life derived from the lessons of Chinese history. The key principles of confucian teaching comprise:

- Social status (social obligation requires 'high-power distance' in relations between individuals, organisations and institutions)
- Collectivism (*Jiti Guannian* 集体观念) (China's attention to the needs of groups, including the family system, has played an important role in generating economic dynamism, sacrificing opportunities for personal gain)
- Interpersonal harmony (achievement of harmonious relationships (*Hexie*,和谐) between business partners)
- Thrift (provision of savings for capital investment)
- Long-term orientation (an appreciation that all social interactions and *guanxi* relationships are within the context of long-term balance).[90]

2.7 Industrial Indigenisation (I^2)

Research into China's aviation industry will be undertaken using survey methods, employing a questionnaire and following-up with intensive interviews (Appendix 2).

The case studies will focus on evaluating performance of the foreign-owned aviation companies, particularly with regard to raising local value–added from both the MNCs' internal production activities and those embedded in the local supply chain. Data will be collected in order to evaluate local value-added performance, including establishing the nature, structure and trends in the development of indigenous innovational capacity, especially in the value chain, and also the degree of skill generation achieved in the aviation firms.

2.7.1 High Value-added Production

Raising value-added in local production is an imperative for securing progression towards the goal of I^2. Industrialising countries recognise the need to increase the technological level and associated local value-adding production inputs, but the typical absence of local capacity and capability in the primary firm and its subcontracting networks makes this no easy task.

Value-added is defined as a build-up in value from input-cost to output-price. Thus value-added in production captures the costs associated with labour, capital, overheads (including R&D) and profit. If local value-added is low, then inputs are likely to be high value-added components and sub-assemblies produced in the MNC's home economy. As a consequence, the FDI recipient company/country will see its value-added 'squeezed' and production will be assembly-based, using unsophisticated worker skills; a classic 'screw-driver' operation. The evidence on MNCs maximizing value-added opportunities for the local economy is contradictory. For instance, a 1995 study commissioned by the New Zealand government found that up to 90 percent of the value-added generated by foreign MNCs was reinvested into the local economy.[91] Whilst the study did not reveal the extent of value-added, it did conclude that FDI had a strong cumulative benefit to the recipient economy, leading to above average wages, the purchase of goods and services, higher payments of taxes, technology transfers, and reinvestment of local earnings.[92] In all, the beneficial effect on the local economy was greater than the profit repatriated to the MNC's home economy. The opposing view is that low value-added activities have shifted from the North to the cheap labour forces of the South. The pattern of development in the South East Asian 'Tiger' economies supports this view, whereby the growth of FDI has resulted in an exodus of manufacturing from the developed world, especially in low value-added sectors; but, this is a simplistic view, because as these economies grow, so will outward FDI.[93]

It is partly the fear that China would be left with a 'static' comparative advantage in low value-added production that prompted the Chinese planning authorities to develop a technology strategy seeking to evolve dynamic comparative advantages in high technology, high value-added industries. As stated earlier, the key aspect of adding value is that it is an important proxy of local industrial development. The more local manufacturers engage in higher technology activities, the higher the worker skills, the higher level of domestic value-added, and the greater will be the progress towards indigenous industrialisation. Policy should, therefore, focus on fostering the growth of these high technology 'strategic' or 'backbone' industries.

2.7.2 Technological Innovation

Technological innovation is a broad concept, but in the context in which it is used here, it means the capability to design and produce next-generation technologies. An innovative organisation is dynamic, engaging in pushing out the frontiers of knowledge. In a sense, it is a measure of progress towards indigenisation and self-sufficiency, because innovative capacities release firms from dependency on foreign suppliers for future product development. The danger is that this may be 'old' technology by comparison to global product technology standards. This, therefore, signals the urgent need for China's aviation companies to move beyond low-technology activities, and, instead, into the design and development of aircraft and associated systems.

This study will seek to establish whether china's aviation companies have progressed from basic level technological capabilities, such as low value-added manufacture, maintenance, and marketing, to the higher levels of innovating new technologies. The need is to achieve an end-state of an organised innovative system that emphasises, formally and informally, technological adoption, modification and advancement. Performance indictors, here, would be R&D investment within the company, and corporate science and technology relationships, patent registrations, university cooperative research programmes and collaborative technology agreements with supplier companies; the latter being important to raise process efficiency, often a precondition for product innovation.

2.7.3 Local Sub-Contractor or Networks

A principal characteristic of technology transfer in the development of aerospace production is the search for low labour cost locations for routine assembly operations. This is still the case today, with the professional and technical occupations more the preserve of the technology transferor countries/regions, such the US, Europe and Japan. The technology-recipient economies, by contrast, are focused on assembly rather than the more sophisticated design and R&D. This is, however, a simplistic explanation of global aerospace production and masks the development of a fairly complex Asian network of manufacturing activities. The South Korean and Taiwanese models have proved remarkably successful because of their pursuance of focused strategies to create innovation and scale, quite often biased towards the development of aerospace foundry work, at least in the beginning, and supported by generous government funding. South Korea's Samsung, in particular, provides a remarkable example of what is achievable. In the mid-1970s, the technology gap between Samsung and the industry standard was around 30 years; today, this gap has long since disappeared.[94]

If China's aviation industry is to achieve success in technological progress, it will need to create 'learning' companies. The study will seek to measure performance in this regard by establishing, for instance, the continued level of dependency on the extent of incompany training schools, the proportions of trained engineers amongst total employees, and the placements and study opportunities in overseas countries. In general terms, this study will attempt to evidence whether investment into human capital has been viewed as a primary goal, and if so, whether the consequent generation of local skills and technical capacity has progressed China's aviation industry towards industrial indigenisation.

References and Notes:

[1] Sutherland, K (ed) Adam Smith: *An Enquiry Into The Nature And Causes Of The Wealth Of Nations- a Selected Edition*, Oxford University Press (1998).

[2] There is no magic formula for successful industrialisation. Newly independent Post WW II countries, such as China, India and those of South East Asia and Africa, starting from the same base, have experienced widely divergent rates of growth and development.

[3] The 'Flying Geese' model was first developed by the Japanese economist, Akamatsu Kaname, in his paper, 'Shinkoku Kogyokoku no Sangyo Hatten', *Ueda Teijiro Hakushi Kinen Ronbunshu*, (July 1937).

[4] Seers, D, 'The limitations of the Special Case', *Bulletin of the Oxford Institute of Economics and Statistics*, Vol 25/2 (May 1963),p75.

[5] Meier, G (Ed), *Leading issues in Economic Development*, Oxford University Press (1976), p75.

[6] Meier, G (Ed), 'Perspective of History: Rostow and Marx - note,' Ibid., p79.

[7] A detailed discussion of the Marxian Views of Capitalist development can be found in many histories of economic thought or economic development textbooks. For example, see Lipsey and Chrystal, *Principles of Economics*, Oxford University Press, 9th Edn. (1999).

[8] Rostow, W, 'The Stages of Economic Growth', *Economic History Review*, (August 1959).

[9] Ibid., Rostow, W, pp 36-40.

[10] These stages are meant to be sequential, one building upon the other.

[11] Cited in Meier,G., Op. cit., p79.

[12] Ibid., p79.

[13] See Kuznets, S, 'Notes on Stages of Economic Growth as a System Determinant' in Eckstein, A(ed.), *Comparison of Economic Systems*, Berkeley (1970), p243.

[14] Meier, G. Op. Cit., p70.

[15] Meier, G. Op. Cit., p81.

[16] Meier argues (p81) that anyone who attempts to impose upon economic history a one-way course of economic evaluation is bound to be challenged, since it is difficult to accept one unique schema as the only real framework in which the facts truly lie; the same facts can be argued in many patterns and seen from many perspectives.

[17] 'Say's Law', see, for instance, Lindauer, J, *Macroeconomics*, Wiley (1968), p300.

[18] Hirschman, A. *The Strategy of Economic Development*, Yale University Press, New Haven (1958).

[19] The Hirschman/Gershenkron hypothesis is that underdeveloped countries can work their way from 'last back to basic and intermediate industries', a process that completely reverses the traditional path of most developed countries which started industrialisation with consumer-good industries. See, Chu Yuan Cheng: *The Machine Building Industry in Communist China*, Edinburgh University press (1972), p231.

[20] Wilber, C, *The Soviet Model and Underdeveloped Countries*, University of N. Carolina Press (1969), p86.

[21] Hirshman, A, Op. Cit., Chapter 6.

[22] Ibid.

[23] Domar,E, 'Expansion and Employment', *American Economic Review* (March 1947), pp34-5 and 'The Problem of Capital Formation', *American Economic Review* (December 1948), pp777-94.

[24] Rosenberg was perhaps the first academic to recognise the importance of capital-efficiency when he argued … 'what is important is not just the development of capital-saving innovation - although this is very important. What is also important is improving the efficiency with which the existing type of capital goods are produced. Underdeveloped countries have been deficient on both accounts but the latter deficiency has received practically no attention. They have, therefore, missed a major source of capital-saving for the economy as a whole. Rosenberg, N, 'Capital Goods, Technology and Economic Growth', *Oxford Economic Papers*, Vol 15 (November 1963), p222.

[25] Both Smith and Ricardo believed that the important factor was labour. Capital could contribute to raising labour productivity and thus improving a country's comparative advantage, but it was there to serve labour. Significantly, both Smith and Ricardo viewed capital as immobile between countries.

[26] David Ricardo's theory of comparative advantage forms the basis for the WTO's advocacy of Free Trade.

[27] E. Leamer, 'The Heckscher-Ohlin Model in Theory and Practice', *Princeton Studies in International Finance* No 77 (February 1995) p1l.

[28] Machine tools were at the heart of Britain's industrial revolution, creating the opportunities for invention and innovation. James Watt's steam engine, for instance, was unworkable for years, waiting for the invention, by Wilkinson, of a horizontal boring machine. In the 20th and 21st centuries, there is

no doubt that the information revolution is being driven by dynamic innovation in aerospace manufacture, including the progressive expansion and miniaturisation of memory capability.

[29] Rosenberg, N, especially his, 'Economic Development and the Transfer of Technology: Some Historical Perspectives', Perspectives on Technology, Cambridge University Press (1976), pp159-60.

[30] Rosenberg, N, 'Technological Change in the Machine Tool Industry 1840-1910', *Perspectives on Technology*, Cambridge University *Press* (1976), pp15-17.

[31] The concept of vertical disintegration was originally coined by, Stigler,G, 'The Division of Labor is Limited by the Extent of the Market', *Journal of Political Economy*, LIX/3(June 1951), pp187-90.

[32] See, for instance, Granick, D, 'Economic Development and Productivity Analysis: The case of Soviet Metal working'. *Quarterly Journal of Economics*, Vol 71 (1957), p200.

[33] As with the other models included in this chapter, the Soviet technology planning paradigm is an *ex post* view, capturing what proved to be the (successful) salient factors characterising the Soviet Union's 1930's central planning regime.

[34] It was an approach which led Granick…'To the tentative conclusion that capital-saving is the motivating principle for Soviet technical change', Granick, D. Op. Cit., p211.

[35] Both India and China have struggled to develop, due, arguably, to overpowering government bureaucracy. However, now that both countries are liberalising, the race is on. See, 'China and India: The Race to Growth'. *The Mckinsey Quarterly*, 2004 Special Edition: China Today. Online http://www.mckinseyquarterly.com/article_page.aspx?L2=19&L3=67&ar=1487&pagenum=1. accessed 15 June, 2005.

[36] The Lagos Plan of Action for the implementaction of the Monrovia Strategy for the Economic Development of Africa, adopted by the Second Extraordinary Assembly of the organisation of African unity (OAU, April 1980).

[37] China's Development strategy largely 'fits' the 'flying-Geese' model followed by the 'Tiger' states. However, the size of China's internal market along with one or two other issues means that China is developing its own unique distinguishing 'Dragon' development strategy. See, Collinson, D, 'Of Dragons, Tigers and Flying Geese', *Nexus*, Warwick University Business School (Summer, 2005), pp8-9.

[38] Guschi, R.' Technology Transfer: Too many Options?' *Chem-tech* (July 1997) pp27-29.

[39] Chooi, K et al, 'Technology Transfer and International Organisations: The Question of Localisation', *Science, Technology and Development - Journal of Third World Science*, Vol 12/No2&3, Frank Cass (August-December 1994), pp198-214.

[40] Bell Martin, 'Learning and the Accumulation of Industrial Technological Capacity in Developing Countries', in Fransman and King (ed.) *Technological Capability in the Third World*, Macmillan, Hong Kong, (1984), pp 187-210.

[41] Technology transfer is typically defined as comprising these elements. For example, Baranson, J, *Technology and Multinationals*, Lexington Books (1978), p350, argues that … "industrial technology consists of product designs, production techniques and managerial systems to organise and carry out production plans."

[42] Al-Ankari, A, *Technology Transfer: A Case Study Analysis of the Saudi Oil and Petro-Chemical Sectors*, Cranfield University PhD Thesis (2004), p15.

[43] Wilkins, Gill, *Technology Transfer for Renewable Energy*, The Royal Institute of International Affairs, Earthscan Publications Ltd., London, (2002).

[44] Al-Ankari, A, Op. Cit., p22.

[45] Jose de Cubas, *Technology Transfer and the Developing Nations*, Multinational Management Education, New York, (1974), p211.

[46] UNCTAD Handbook of Statistics On-line http://stats.unctad.org/restricted/eng/TableViewer/wdsview/dispviewp.asp,

[47] Hertz, N, 'The Silent Takeover - Global Capitalism and the Death of Democracy,' Random House Group (2001), p43.

[48] Two of the most influential writers in this field are Hymer, S, *The International Operations of National Firms: A Study of Direct Foreign Investment*, Cambridge, MA: MIT Press (1976) and Dunning, J, 'Towards an Eclectic Theory of the International Production: Some Empirical Tests', *Journal of International Business Studies*, Vol. 11(1980), pp9-13.

[49] Dunning argued that three conditions must be present for FDI to take place: that there be ownership-specific advantages not possessed by competitor firms; that the foreign firm must successfully 'internalise' these advantages in the 'host' economy; and that there must be locational factors so that FDI in a foreign land is a profitable exercise. See, Dunning, J. *Multinational Enterprises and the Global Economy*, Addison Wesley (1993).

[50] Perhaps the most significant contribution to the role of FDI and the locational dimension is, Vernon,R, 'International Investment and International Trade in the Product Cycle', *Quarterly Journal of Economics*, Vol 80 (1966) ,pp190-207.
[51] See, for instance, UNCTAD: '*Transfer and Development of Technology in the Least Developed Countries: An Assessment of Major Policy Issues'*, UNCTAD ITP/TEC/12,UN,Geneva (1990) and UNCTAD: *The Interrelationship Between Investment Flows and Technology Transfer: An Overview of the Main Issues*, UNCTAD/ITD/TEC/1, UN, Geneva (November 1992).
[52] See, Caves, R.E. *Multinational Enterprise and Economic Analysis*, Cambridge, UK, (1982), p226.
[53] See Teece, D, 'Technology Transfer and R&D Activities of Multinational Firms: Some Theory and Evidence', Hawkins, R and Prasad, J (Eds) *Research in International Business and Finance*, Vol. 2. JAI Press (1981).
[54] See, Caves, K, Op. Cit., p211.
[55] OECD, '*Open Markets Matter - The Benefits of Trade and Investment Liberalisation'*, (1998), p36.
[56] OECD, ibid., p34.
[57] Sourced from OECD, ibid., p9.
[58] Ransom, D. The *No-Nonsense, Guide to Fair Trade*, New Internationalist Publications (2001), p233.
[59] In the UK in 1997, FDI represented 26 percent of manufacturing net output. *Fact Sheet Investing in the UK* (2003), http://www.number-10.gov.uk/output/Page1419.asp
[60]FDI has the potential benefit of narrowing technology gaps between the rich and poor nations. See, Cantwell, J, 'Innovation and Information Technology in MNEs', *The Oxford Handbook of International Business*, Oxford University Press, (2001), pp432-3.
[61] This is, of course, the principal attraction for MNCs entering into the Chinese market.
[62] China, through linking into TNT's international operations, has now become emeshed into a global transportation and logistical network. See, 'Midnight in Memphis, New Dawn in China: the World's Supply Chain Battle', *The Financial Times*, (9 August 2004).
[63] Porter, M, was perhaps the first academic to recognise the importance of technology clusters, see his 'Diamond' model in *the Competitive Advantage of Nations*, Macmillan (1990).
[64] According to Stiglitz …'Soft drinks manufacturers around the world have been overwhelmed by the entrance of Coco-Cola and Pepsi into their home markets.' Stiglitz, J, *Globalisation and its Discontents*, Penguin (2002), p68.
[65] For example, over the last 10 years FDI has increased in central Europe whilst GDP has dropped, suggesting that FDI benefits may not match the costs of inducement. See 'Foreign Direct Investment: A Lead Driver for Sustainable Development?' *FDI Briefing Paper* http://www.earthsummit 2002.org/es/issues/FDI/fdi.rtf
[66] MNCs, because of their size, have significant power over the host economy. Ultimately, they threaten to transfer production to another country. See 'World-beater Inc', *The Economist* (20 November, (1997).
[67] The McDonald's fast self-service restaurant eating culture is now seen, but not necessarily welcomed, throughout the world.
[68] MNC manipulation of revenue and profit through transfer pricing often means that foreign firms run at a loss, depriving the recipient economy of legitimate corporation tax.
[69] Ransom, Op, Cit., (p75) argues that multinationals avoid having to pay the … 'real environmental costs'.
[70] Ransom, D, p125.
[71] Ransom, D, p125.
[72] Smith, D, Free *Lunch - Digestible Economics*, Profile Books (2003), p189.
[73] Stiglitz, J, *Globalisation and its Discontents*, Penguin (2002), p72.
[74] Stiglitz, J, ibid., p72.
[75] This is the traditional view, though it may be changing. Note that there are now more than 300 foreign R&D centres in China. See, Collinson, D. Op. Cit., p9. Motorola, for instance, has 13,000 employees in China, including 1,000 R&D employees. Whilst cutting 39,000 jobs worldwide, the company has plans to expand the number of R&D workers in China. See, 'Motorola to Invest US$3 billion in China Expansion', *The Financial Times* (9 November, 2001).
[76] Mitchell, B and Ravenhill, J, 'Beyond Product Cycles and Flying Geese - Regionalization, Hierarchy, and the industrialisation of East Asia', *World Politics*, (January 1995), p172.
[77] See, Rosen, D, 'Low-Tech Bed, High-Tech Dreams', *China Economic Quarterly* (Q4, 2003) Table 4, p23.
[78] Mitchell, B and Ravenhill, J, Op. Cit., p173.
[79] Mitchell, B and Ravenhill, J, Op. Cit., pp173-77.

[80] See, R. Matthews and R. Williams, 'Technology Transfer: An Examination of Britain's Defence Industrial Participation Policy', *RUSI* (April 2000).
[81] R, Matthews, 'Saudi Arabia's Defense Offset Programmes: Progress, Policy and Performance", *Defence and Peace Economics*, Vol. 7 (1996), p235 and p248.
[82] See, *Shelling out – How Taxpayers Subsidize the arms trade*, http://www.caat.org.uk/campaigns/shelling-out/briefing.php
[83] Zhang Yi, Zhang Zigang, Men Xiaobo, Huang Shengjie, 'Determinants of Structural Change to Sequential Foreign Direct Investment across China: A Synthesised Approach', *Singapore Management Review*, Vol 26/1 (2004), p64.
[84] Luo, Y and O'Connor, 'Structural Change to Foreign Direct Investment in China: An Evolutionary Perspective', *Journal of Applied Management Studies*, Vol. 7/1 (1998), pp95-109.
[85] Porter, M, *The Competitive Advantage of Nations*, Macmillan, London (1990).
[86] Note, however, that country strategies might differ. For instance, Taiwan has a private sector aerospace industry, promoted through protective tariffs and government hand-outs, but was nevertheless guided and nurtured through government patronage. Korea, by contrast, used government control and ownership of major industries, such as the telecommunications industry, and also the chaebols, to facilitate the development of a local aerospace industry. For a deeper discussion of Asian's aerospace industry development, see Mathews, J and Cho, D-S, *Tiger Technology: The Creation of a Aerospace Industry in East Asia*, Cambridge University Press (2000).
[87] Singapore's strategy to develop local biotechnology and nanotechnology industries through a generous government financial sponsorship programme is a case in point.
[88] See, for instance, Sull, D and Yong Harry Wang, *Made in China: What Western Managers Can Learn from Trailblazing Chinese Enterprises*, Harvard Business Press (2005) and Wood, E, Whitely, A and Shiquan Zhang, 'The Cross Model of Guanxi Usage in Chinese Leadership', *Journal of Management Development*, Vol. 21/4 (2002), pp263-71.
[89] Individuals who have 'good' guanxi with each other do not use bribery; the latter is only used when there is mistrust. See, Davies,et al, 'Guanxi and Business practices in the People's Republic of China', and Alon, I (ed) *Chinese Culture, Organizational Behavior and International Management*, Praeger Publishers (2003).
[90] As part of their culture, the Chinese seek balance (*Yin and Yang*) in their social and business relationships. See, Chan, Y, et al, 'The Dynamics of Guanxi and Ethics for Chinese Executives', *Journal of Business Ethics*, Vol. 41 (2002), pp327-36 and Tsang, W, 'Can Guanxi be a Source of Competitive Advantage?' *Academy of Management Executive*, Vol. 12/2 (1998), pp64-73.
[91] Cited in Open-Markets Matter - The Benefits of Trade and Investment Liberalization', OECD (1998) p35.
[92] Ibid., p35.
[93] Ibid., p35.
[94] Yet, these and other Asian countries have actively sought greater indigenisation and value-added as part of an evolutionary process. East Asian manufacturers have moved through three development stages: low cost sites; upgrade from simple activity to more complex activity; and greater manufacturing autonomy through the development of regional networks. Predominantly, US aerospace firms managed the initial technology transfer and now manage the deepening division of labour between the US and Asia, exploiting increased specialisation in the Asian countries. See, Borrus, M, 'The Resurgence of US Electronics: Asian Production Networks and the Rise of Wintelism', Borrus, M et al (Eds) *International Production Networks in Asia: Rivalry or Riches?* London, Routledge (2000).

Chapter 3 Regional Dynamics: Flying Geese, and the Development of Asia's Commercial Aviation Industry

3.1 Asia's High Technology Ambitions

The last chapter was concerned with critically evaluating the literature on broad development strategies. These included development approaches, such as Rostow's 'take-off' model, trading regimes, such as import substitution, and industrial and technology paradigms, including the development vehicles for acquiring technology, and here FDI and offsets were argued to be important. The analysis of the literature was generic in the sense that it was not sector specific. The message was clear, however; industrialising countries seek greater technological sovereignty, having ambitions to acquire design and manufacturing capacity in increasingly high technology industries, but in the absence of high-level skills, local supply chains and high value-added operations, domestic capability will remain superficial. Figure 2.10 offers a framework of analysis that reflects these development priorities.

The purpose of this chapter will be to apply this framework to the development of Asia's commercial aviation industry. Thus, given the almost complete lack of empirical investigation in this subject area, particularly directed towards 'indigenous industrialization' (the research lacuna) the dissertation now applies the framework to a regional and sectoral context. Chapter 3 examines Asia's progress in aviation development. It is heavy on empirical detail and employs the 'Flying Geese' model, as discussed in Chapter 2, to investigate manufacturing performance facilitated by inward technology transfer. This comparative evaluation sets the benchmark for the subsequent country case study of China, in terms of its macro development, technology planning and development process (Chapter 4), and analysis of the extent of indigenous industrialisation achieved in the domestic aviation sector (Chapter 5).

3.2 Asia's Flying Geese Technology Development Paradigm

The flying geese thesis derives from the work of a Japanese academic, Professor Kaname Akamatsu.[1] His model took shape in the 1930s, but further elaboration of the theory was conducted after the Second World War.[2] Akamatsu was concerned to explain and analyse the nature of production and trade in Japan's technology industries before the Second World War. His writing evolved into a technology development theory that he described under the Japanese lyrical name. *Gankoo Keitai* (Flying Geese). The model is very much focused on the transfer and dissemination of technology across countries, and in that sense it mirrors the process involved in Vernon's 1966 International Product Life Cycle that was analysed in Chapter 2.[3]

The Flying Geese model traces the introduction of a new product into Asian countries via imports. Later, these same countries having absorbed the technology become exporters (corresponding to the decline phase in the product life cycle thesis). In the analysis of these trading patterns, Asia became segmented into three groups of countries according to the level of development reached: Japan as the technological head (*Senshinkoku*) the newly industrialising countries (NICs) (*Shinkookoku*); and, finally, the ASEAN4 countries.[4] Akamatsu's theory was that industrial development in Asia would 'trickle-down' from Japan to the NICs and then to the ASEAN4. A five-stage life-cycle of technological advance is associated with Japan and the other two groups of countries in Asia's economy. This life-cycle traces the gain and then loss of comparative advantage, leading to the relocation of production across Asian countries experiencing different levels of technological maturity. The five stages of the technological life cycle can be applied to any typical industry. This part of the model incorporates the features of Akamatsu's 1960's papers, and also the later elaboration by Dowling,[5] adopting the notion of Yamazawa,[6] of a final decline stage in the relocation of technology to other countries; the five stages are explained, below:

1. A country enters into the process of technology development through imports of industrial goods from an advanced country. This eventually induces local production as domestic demand expands. However, foreign imports continue, as the quality and production costs of local output is inferior to foreign imports.

2. Stage two is where the government aims to accelerate the process of local industrialisation and technological development through an import-substitution strategy. The encouragement of local demand via this approach must be made to work through the erection of tariff barriers and associated import restrictions. This process occurred in the ASEAN4 in the 1970s. Protectionism, combined with long production runs of standardised goods, provided the conditions for scale and related competitive advantages. FDI starts to emerge, but at this point in the life-cycle it is relatively unimportant. As Dunning explains, this lack of foreign investment preparation may be due to numerous factors, including low per capita income levels, weak protection of IPR, and scarcity of skilled labour and the under-development of a transportation and communications infrastructure

3. Stage three occurs when exports of the particular good take-off, with the likelihood that domestic demand is growing at a reduced pace. Strong export performance allows rising imports of capital goods, further expanding capacity and capability. Inward FDI also increases as advanced country production ceases because of the loss in comparative advantage. As development in the Asian country proceeds, it is likely that skills and infrastructure will improve, with the entire industrial sector becoming a much more viable commercial proposition.

4. Stage four is the maturity phase, with growth in demand and production slowing in the face of market saturation, rising cost, and rising competition from other late-comers to the industrialisation process. Significantly, inward FDI also starts to reduce as MNCs search for other more profitable production bases in Asia.

5. The final life-cycle stage is when production costs become so high that inevitably there is a loss of comparative advantage. As a consequence, production will locate to other Asian countries in a lower development group. Import of the goods will now come from the emerging *Kooshinkoku*. The local Asian economy must then look for the opportunity to develop other higher value industrial comparative advantages.

There are numerous interpretations of the technology five-stage life-cycle theory, including the nature of transition between stages, the extent of foreign competition, the sequential and concurrent nature of the cycles, and the degree of supportive government intervention. With regard to the latter point, as the domestic economy grows under an import-substitution strategy, the depth and sustainability of development is dependent upon government support. This may be in the form of credit if local finance markets are immature, and might also include training, support for capital goods acquisition and technological know-how, participation in trader fairs/exhibitions, and possible loans for R&D funding. Whilst protectionism defines an import-substitution regime, it is also critical that competitive forces are encouraged. Finding such a balance will not be easy, but is essential if a speedy transition is required from import substitution to export promotion. This was a positive feature of the South Korean and Taiwanese technology development models, but India, by contrast, suffered from decades of stagnant economic growth due to overpowering bureaucratic regulations and trade protection, stifling industrial competitiveness.

Akamatsu's early writing's emphasise a development process that moves smoothly from one country to another; the follow-on Asian countries continuously trying to catch-up with the lead state, with the latter locked into a global competitive race, seeking to close the technology gap with Western economies. Thus, Akamatsu's description of this regional 'trickle-down' development process conforms to a 'harmonious paradigm'.[7] Cheap imports undermine local production, and eventually domestic investment migrates from this declining industry to new 'sunrise' sectors. A dynamic comparative advantage evolves at differing levels of technological capability across the Asian countries. In this way, the technological hierarchy is maintained, with Japan firmly installed as the lead goose.

Another assumption of the flying geese model is that the Asian region will experience rising levels of economic integration and interdependence, as countries become increasingly dependent on each other for cheap imports and exports. This inter-industry trade will be driven by the spectrum of differential comparative advantage levels achieved across the regions in the specialisation of complementary goods. The role of

FDI is important because it acts as the vehicle for technology transfer, as per Vernon's model. The technologies transferred, moreover, will act to elevate recipient country comparative advantages through relocation of technical, managerial and financial resources. Although inter-industry trade occurs between countries at different development stages producing complementary goods, the inevitable next step is for industrial production to take-on greater levels of technological sophistication and complexity, reflecting intra-industry trade. In other words, Asia's producers become part of a regional (Japanese) global supply chain. The production and export of intermediate products, eg microelectronic wafers, in the case of Taiwan, will be encouraged, reflecting an international integration of manufacturing activities at an intra-industry level. One final, but significant, point is that if intra-industry trade is heavily influenced by MNC investment, it invariably carries with it the disadvantage that production is low value added, with limited stimulus given to the creation of local value chains. Thus, if/when local industry loses its competitive advantage, foreign MNCs possess the potential to relocate capacity to other countries enjoying relatively high cost efficiency. This process acts to temporarily retard development through what is termed industrial 'hollowing-out', as occurred in Singapore in the 1980s.

The origins of Akamatsu's flying geese model lie in his analysis of the historical evolution of Japan's textile industry. His comparative framework of analysis was the development of European capitalism and, of course, at the heart of Europe's first industrial revolution lay the technological development of Britain's textile industry. In the global scheme of economic affairs, Akamatsu viewed Japan as assuming an intermediate position, as the technology leader in its own geographical sphere of influence.[8] Furthermore, he conceptualised that economic and trade interrelationships between countries in this sphere of influence would give rise to … "an awakening of less developed areas of the world to modern economic development."[9] The process of development would be effected through periods of 'heterogenization' and 'homogenization'. In the former period, divergent relative costs lead to a change in production structure based on an evolving international division of labour in complementary outputs. By contrast, the homogenization period may be characterised as a process of substitution and competition between countries whereby imports lead to domestic output that later feeds through into exports. Moreover, development occurs via the traditional route of, firstly consumption goods industrialisation, later extending to capital goods production. Here, again, the development experiences of South Korea and Taiwan are instructive. [10]

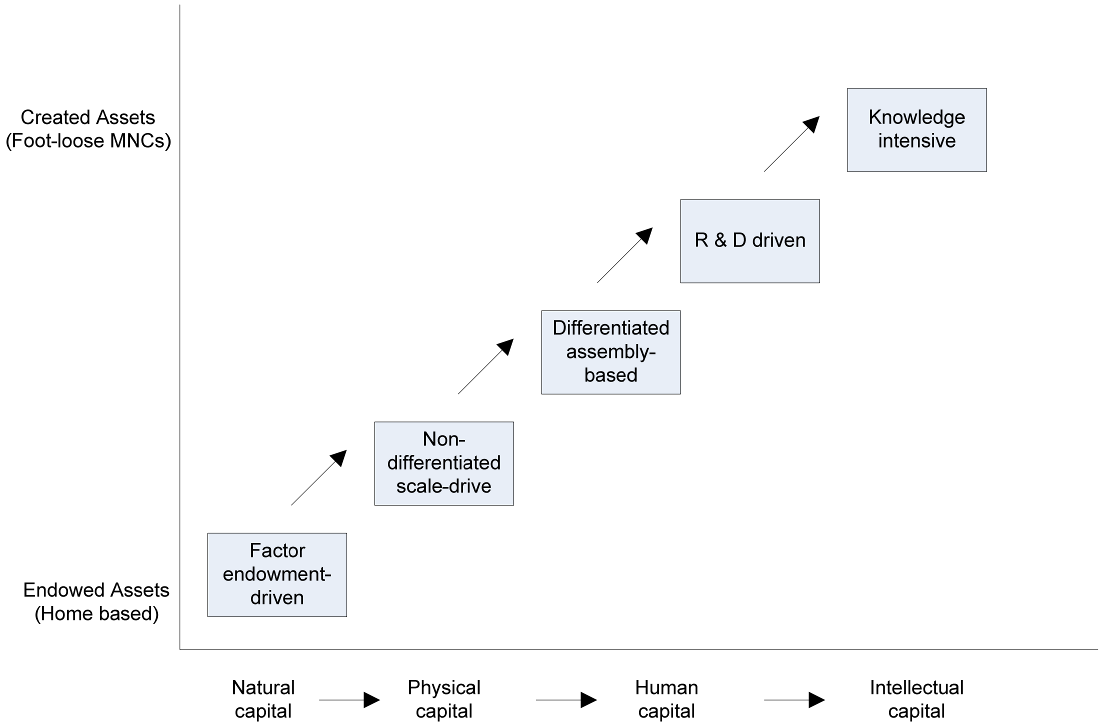
Ginzberg argues that, intuitively, theory links to the positive role that foreign imports and investment have in the process of development. Importantly, he argues that:

> "…contact with foreign artefacts and culture, and in particular imports…may trigger off a process of development through a succession of steps which present not only technological and economic aspects (on both the cost and demand side), but also learning and cognitive dimensions." [11]

Kojima elaborated on this process by emphasising that, especially for Japan, domestic structural transformation occurred through government interventionist policy identifying a 'leading growth sector', *a la* Schumpeter.[12] Here, industrial upgrading occurs periodically, accentuating a sequence of growth by stages, in each of which a certain industrial sector can be identified as the main engine of structural transformation to a higher level of value-added.[13] Arguably, no Asian country to date has achieved such a rapid process of structural upgrading as has been experienced by Japan since WWII. Japan moved rapidly through the various stages of industrial transformation: from Heckscher-Ohlin industries (textiles, 1950-mid-1960s), to scale-driven non-differentiated Smithian industries (steel and shipbuilding, late 1950s-early 1970s), to assembly-based differentiated industries (automobiles and white-goods, late 1960s), to R&D-driven Schumpeterian industries (computers, telecommunications and aircraft, mid-1980s), and to the most recent stage, knowledge-intensive industries (bio-technology and nano-technology, mid-1990s). [14] These waves of industrial transformation are conceptualised in Figure 3.1.

The key to Japan's technological success was not just access to foreign technologies but absorptive capability. Certainly, there was imitation of design, but subsequently the process was local adaption and improvement, particularly in efforts to raise the potential for commercialisation. Associated improvements included attempts to raise productivity through improved production organisation, lean production, Kaizan, and

Figure 3.1: Phases of Industrial Transformation



Source: adapted from Ozawa,T, 'Pax Americana-led Macro-Clustering and Flying-Geese-Style Catch-up in East Asia: Mechanisms of Regionalised Endogenous Growth', *Journal of Asian Economics*, 13,(2003), p702.

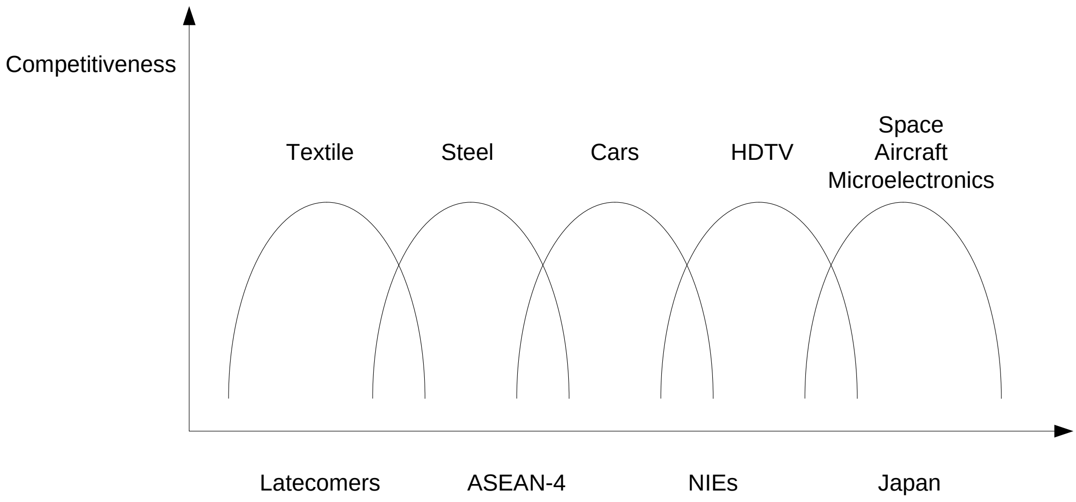
Just-in-Time techniques. This whole process of technology import/licensed production, absorption, and modification, led to sustainable local production and ultimately to export, as depicted in the flying geese model. Moreover, in the Japanese case, innovational pressures accompanied the process of industrial transformation. This innovational aspect was facilitated by Japan's industrial maturity, as reflected by both flexibility and specialisation in industrial structure. The role of specialist suppliers was critical to the success of the Japanese model. They are characterised by networks of competitive but also cooperative suppliers of parts, components and sub-assemblies. The final good (prime) contractors would outsource selected vertical integrated stages of production to SMEs located in the value chain, as Ozawa notes…

> "…because of the 'dual' (or actually multi-layered) industrial structure of Japanese industry (where large, medium and small firms coexist in close affiliation), process fragmentation (vertical specialisation) has become all the more fine-tuned to make use of different labour costs and technological capabilities of suppliers at divergent levels of Japan's industrial hierarchy …as Japan moved up the ladder of structural upgrading, each tier of industry became *vertically differentiated* in technological sophistication, value added, product quality, and factor intensity. For example, in…the assembly-based automobile industry, cars are differentiated by high-end versus low-end models, and its parts, components, and accessories by high value-added key components versus low value-added peripherals…each higher tier of industry, thus, offering to developing countries opportunities to participate in some low-end segments of production and service which are commensurate with their levels of technological sophistication and wages. In other words, developing countries with advantages in labour-intensive standardised goods can now join not only in lowest-tier (Heckscher-Ohlin) light industries but also in the low end of *each* of the higher-tier industries. Thus, an *intra*-industry vertical division of labor occurs across borders, along with an *inter*-industry horizontal division of labor…"[15]

This evolutionary process (see the 'Western' model of technological development, section 2.3.1, chapter 2) of industrial transformation and technological upgrading defines Akamatsu's flying geese paradigm. Progressive restructuring of Asia's lead goose, Japan, has been a powerful influence on the industrialisation pattern of other East Asian Countries. As Japan lost comparative advantage in low productivity tiers (low- end goods at each tier), it transplanted *via* FDI those disadvantaged industrial activities to other Asian economies (first to the NICs, then ASEAN 4, and most recently to China) where production was competitive.[16]

In summary, then, Akamatsu's flying geese model has relevance to the development processes of underdeveloped countries. In recent decades, the US (and increasingly European advanced countries) has acted at the global level as the initiating mechanism for the transmission of technology to the developing states.[17] In this respect, the US represents the lead goose, via its MNCs, in transferring technology to other countries. Importantly, though, the higher the technology level of the recipient country, the higher the technology package that is transferred: Japan, as a high technology country, therefore, continues to play a pivotal role in Asia's technology dissemination cycle. As it moves up the technology ladder, often via US-sponsored infusions of technology through licensed production (technology offsets) and increasingly international strategic alliances, Japan will cascade down to other Asian countries those vertical production process where it has lost its comparative advantage. Figure 3.2 diagrammatically illustrates this regional transformation process. As mentioned earlier, the flying geese model aligns with Vernon's IPLC thesis, with both models depicting 'dynamic' transformational processes rather than any form of classical equilibrium model. Across Asian economies characterised by differing levels of economic development there will be homogenisation, though not replication, of industrial structure. Alien technologies, both product and process, will be transferred, but will differ not only because of the different stages of technological sophistication, but also because of the variegated culture mix; that is the unique 'cocktail' of foreign and indigenous business cultures. The nature and pace of technology diffusion from Japan to other states will be determined by the latter's possession of skills, efficient cost structures, scale potential, innovational capacity, and '2nd-mover' prospects. The catalyst for technology diffusion occurs after the recipient country establishes domestic demand through imports of the technology. What follows will be local licensed production and, ultimately, exports. Import substitution strategy will likely be pursued once local production begins, reflecting the need to protect the vulnerable 'infant' industry. Throughout this process of regional industrial transformation, there exists the possibility of 'leap-frogging' certain of the vertical stages of production, but it is impossible for any follower to close the technology gap with the 'lead goose' in one giant leap. A measured pace in the acquisition of skills and technology necessarily means that …"taking the existence of international trade for granted, the industrial development of less advanced countries, will as a matter of course, take the form of a wild geese pattern from crude goods towards elaborate goods."[18]

Figure 3.2: Asia's International Division of Labour



Source: Okita, S, 'The Flying Geese Pattern of Development', *4th Pacific Economic Cooperation Council Conference*, Seoul, (1985).

Note: "Wild Geese are said to come to Japan in Autumn from Siberia and back to the North before Spring, flying in inverse V shapes, each of which overlaps to some extent", Akamatsu (1961), pp 205-6.

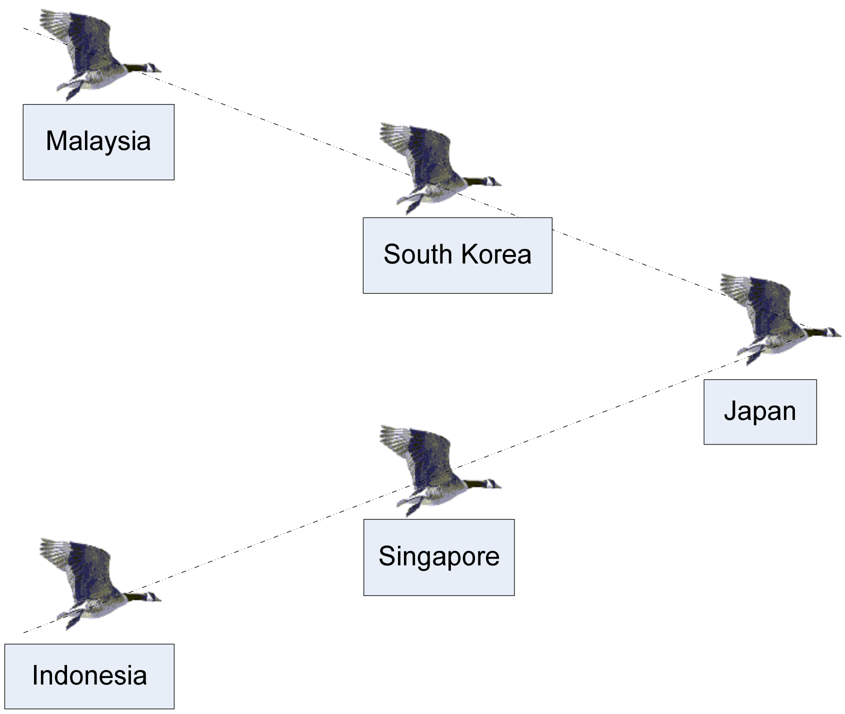
3.3 Flying Geese Model Applied to the Development of Asia's Commercial Aviation Industry

Although the Flying Geese Model is normally discussed in generic terms, it can be applied to the development of a particular industrial sector. Indeed, as was stated earlier, Akamatsu himself originally applied the model to the development of Japan's textile industry.[19] Work has also been undertaken on applying the model to the development of Asia's electronics sector.[20] Taking these applied applications as a cue, the present study seeks to apply the flying geese model to the development of Asia's commercial aviation industry, including (in Chapter 5) the case of China. This comparative analytical framework does not strictly conform to every aspect of Akamatsu's theoretical approach. For instance, the contemporary technology trickle-down from Japan does not occur, because FDI investments in commercial aviation have been channelled directly from Western OEMs, such as the US, Britain and France. Moreover, globalisation has changed the nature of the production process. During the era in which Akamatsu wrote, national production would have meant exactly that, an aircraft comprising parts, components and systems produced within the country.

Commercial aircraft production, therefore, would have been confined to the advanced industrialised countries possessing the necessary resources. Today, a commercial airliner is likely to have systems and assemblies sourced from numerous countries; for instance, engines from the UK, avionics from France, and systems from the US or Germany. Intra-industry linkage 'between' Asian countries remains a feature of the development process but alongside rather than detached from advanced country foreign investment.

Akamatsu's flying geese model, then, can be applied to Asian commercial aerospace industrial development, but FDI is driven by foreign Western OEMs, with the nature of technology transfer influenced, as in the original the flying geese model, by the relative technological maturity of the recipient Asian countries. The degree of technical competence and market attractiveness, thus defines the technology hierarchy characterising the Asian commercial aviation context. Therefore, at this regional level, the widely held view is that Japan remains undisputedly, the lead goose. The followers, in order of industrial and technological capacity, are South Korea, Singapore, Malaysia and Indonesia. Until recently, China would not have been included in this Asian aviation flying geese model, given its lack of production capacity, but this no longer holds. China has quickly transformed itself into a major regional aerospace player, and this rapid sectoral development needs to be recognised. So, the analytical approach adopted in this study will, firstly, be to examine the industrial status of Asia's aviation countries according to the revealed technological hierarchy mapped by reference to the Flying geese model. Figure 3.3 illustrates this horizontal 'V' shaped hierarchy, with Japan as the lead goose, followed by South Korea, Singapore, Malaysia and Indonesia. Additionally, an attempt will be made to profile the development characteristics of China's emerging commercial aviation sector. China is not formally included in Figure 3.3 as it represents a focused case study in chapter 5. In any case, with a lowly 2006 sales volume of RMB7.27bn (US$1.06bn), it only just makes the tail-end of the Flying Geese Model. [21] Chapter 5 will focus on analysing the extent of industrial indigenisationthat China has achieved in the development and production of commercial passenger aircraft. China's dynamic profile in this study's applied (see Chapter 6) aviation Flying Geese Model can then be judged.

Figure 3.3: Flying Geese Model Applied to the Aviation Industry



Source: Author

3.3.1 Lead Goose: Japan

Japan presently has a strong diversified domestic aerospace industry. It comprises several key players, such as Mitsubishi Heavy Industries, Kawasaki Heavy Industries and Fuji Heavy Industries. Apart from these major prime contractors, Japan possesses high numbers of small and medium size specialist sub-contractors, such as Showa Aircraft Industry, Yokogawa, Jamco, Matsushita Avionics and Systems and Sumitomo Precision Products. Although the sector comprises space, commercial aircraft, and military planes, it is the latter area where Japan's aviation origins are to be found. Japan's military production heritage is pre-WWII. Through cooperative industrial Agreements, with particularly the US defence and aerospace industry in the1930s, Japan essentially became self-sufficient in aviation production by the start of the Pacific

War. By war-end, Japan was already testing proto-types of military jet fighters and the roots to successful aerospace production were sown. Post-war, the principal thrust of Japanese aircraft production continued to be directed towards military output. Licensed production of US systems, including F-86 fighters and T-33 trainers, commenced in the early post-war decades.[22] These early beginnings were consolidated by later technology transfer in the licensed production of F-4 fighters and F-15 Eagle fighters. Mitsubishi was heavily involved in these military programmes and was the prime contractor in 1996 for the ‘semi’ indigenous F-2 fighter. Some 40% of the subcontract work was channelled to US defence contractors, not least because the F-2 was to all extents and purposes an upgrade of the US F-16 fighting Falcon aircraft.[23] Nevertheless, many of the high tech. systems integrated into the F-2 were Japanese supplied, including advanced electronic equipment, such as phased-array radar, composite materials and other state-of-the-art technologies. Additionally, Japan excelled in helicopter production. In the mid-1990s, Japan developed its first indigenous rotary-wing aircraft, the light observation (OH-1) helicopter. Here, it was Kawasaki Heavy Industries that was selected as the prime contractor, but, significantly, in Japanese aerospace programmes, much of the subcontract work is always supplied to the other primes, such as Mitsubishi and Fuji.

Japanese commercial aircraft production, not just military combat aircraft production, suffered from the Allied Occupation Forces ban on aircraft manufacture from 1945 to 1952. This delayed Japan's efforts to create and expand local capacity. However, right from the start, Japan had ambitions of developing an indigenous aircraft industry. Very quickly, in the late 1950s, it launched its first post-war 'Japanese' commercial aircraft, the 60-seat propeller-driven YS-11. The aircraft was in production from the late 1950s to the early 1970s, and ...

> “Even though the aircraft was technically sound, it was a commercial failure, with less than 200 eventually being sold. Nakamoto argued that the downfall of the YS11 was caused by the global market's preference for the jet engine alongside the Japanese aerospace companies' lack of marketing capability. The other point, which remains a characteristic of emerging aerospace production

> across the world, is that whilst the YS11 was a domestic design, it relied heavily on imported or co-produced engines. Avionics, and other major subsystems."[24]

Japan's ambitions to develop domestic commercial airliner capacity did not disappear, however. They resurfaced again in the 1990s when discussions between government and industry took place over plans to develop a Japanese-built YXX 150-seat plane and a YSX 50 to 100 seat plane.[25] These discussions did not lead to any tangible results, and until recently Japan's policy approach has been directed more towards international cooperation.

Japan's push for international aerospace cooperation intensified efforts that had begun as far back as 1986. This was when Article 1 of the country's Aircraft Industry Promotion Law was revised from... "promotion of domestic development of aircraft and aeroengines and the subsequent reduction of the trade deficit"… to… "promotion of joint international development of aircraft and aeroengines and the subsequent facilitation of international business exchange." [26] However, increased industrial cooperation does not mean that Japan had abandoned its ambitions of a fully Japanese aerospace industry. The fact is that many leaders in government and industry still have the goal of indigenous production of aircraft and engines, but the strategy is that it would be pursued through long-term international collaboration. [27] According to Samuels, Japan's search for technology, centres around three distinct but interrelated values:

- **Autonomy or indigenisation (*Kokusanka*):** Japan's capability to design and produce its own aircraft without dependence on foreign countries.
- **Diffusion (*Hakyu*):** involvement in the adaption, assimilation, and diffusion of technologies, often acquired from foreign countries. Technology spin-off of the aerospace industry's exacting technologies can lead to advancement in other horizontally and vertically structured industries, such as electronics, machinery, materials, shipbuilding and automobiles.
- **Nuturance (*Ikusei*):** a description applied to efforts by the Japanese government to manage industry competition and 'nurture' technological development.[28]

The structure of Japan's aviation industry is essentially the same as during WWII. Four companies dominate the sector, but the share of aerospace in overall corporate activities is low, accounting for only 15% of revenues in the late 1990s.[29] Ishikawajima-Harima specializes in engine production, and MHI and KHI are involved in the production of engine components. MHI, KHI and FHI specialise in the manufacture of airframes and related components, and as mentioned earlier, KHI and MHI also have a significant involvement in helicopter development and production.

These four big industrial conglomerates have participated in numerous major international aerospace programmes over recent decades, propelling Japan to the premier 'Asian' position in global aerospace rankings. Japan's principal strategic alliance has been with Boeing, driven by the need to risk-share, enhance technological capability, benefit from market entry, and participate in profit distribution. The first big venture was the late 1970's 767 programme, in which Japanese firms took a 15% production share.[30] The Boeing 777 followed in 1991, with the Japanese share of aircraft structures accounting for 21% of total production.[31] More recently, in 2004, the Japanese Aircraft Development Corporation (JADC - comprising MHI, KHI and FHI) signed a Memorandum of Agreement for Japan's participation in the development and production of the Boeing 787 Dreamliner. Japanese firms will be responsible for supplying the main and centre wing box, forward fuselage section, main landing gear wheel well, and the main and wing fixed trailing edge, accounting for approximately 35% of the 787 structures.[32] In addition, Japanese firms have been heavily involved as subcontractors in the Airbus family of aircraft, including the A300, 310, 320, 330, and 340 aircraft. As at October 2004, some 21 Japanese companies were participating in the development of the A380, the flagship of the Airbus Fleet.[33] In the field of aero-engines, Japan's aerospace firms are participating as subcontractors/partners in the development and production of General Electric and RR Trent 1000 engines for the Boeing 787 and similar engines for the Airbus A380. Moreover, Japan has participated as a full partner in the global consortium of aeroengine producers that developed and produced the V2500 engine.

3.3.2 The Lion State (Singapore)

Singapore gained Independence from Britain in 1965 and immediately set about building its economy. Given the small size of the country it was inevitable that strategy would be directed towards integrating Singapore into the global economy. Demand would be export-oriented, with domestic capital accumulation provided by FDI. In similar vein, the development of Singapore's aerospace industry has followed the country's macro model. Partnership was important, though at the international level it was not the dominant feature. The fact is that once capacity had been established, the goal of local skill generation as a means of securing operational efficiency and market competitiveness were equally as important.

Singapore's principal aerospace company is ST Aerospace. It started operations in 1975, just 10 years after the country's Independence. Within two years, it had entered into a joint venture with Eucocopter and began to participate in the fabrication of helicopters. During the following three decades, ST Aerospace experienced rapid growth and development in the range of its activities. There were several reasons for this expansion of activity. Firstly, the company was able to benefit from the technological synergies of being part of ST Engineering, a diversified industrial conglomerate. Although quoted on the Singapore stock exchange, ST engineering is a Government Owned Enterprise (GOE), jointly-owned by the public (49.2% shareholding) and the government-owned body, Temasek (50.8%), and capitalised at S$ 10.24bn (February 2008) making it the nineth biggest company in Singapore. [34] Aerospace is one of ST Engineering's four Strategic Business Unit (SBUs), the others being Electronics, Kinetics and Marine. Moreover, Aerospace accounts for a sizeable proportion of the conglomerate's total sales. In 2007, out of total sales of S$5.05 bn, ST Aerospace at S$1.835 mn, accounted for 36% of corporate revenue.[35]

The second reason behind ST aerospace's rapid expansion, and building on the earlier discussion of technological synergies, ST aerospace fuelled its growth by linking with the other SBUs in developing industrial expertise in defence production. In this regard, ST aerospace, whilst growing through International Cooperation Programmes (offsets) from substantial MINDEF orders for foreign-supplied combat aircraft, the aerospace division was able to promote in-house expertise by sourcing elements of the electronics and other systems capabilities from sister commercial SBUs.[36]

Thirdly, the complementary industrial division of labour characterising ST Engineering's organisational structure was no accident, but rather a deliberate planning policy to ensure that the breadth and depth of high engineering skills could be fostered to enable divisions to bid for work in their defined sectoral areas, supported by the assurance that specialist capacity would be available within the company for high value systems inputs, such as electronics. This capacity-building was in parallel with the specialist activities evolving within the division. For ST Aerospace, one of its core areas of specialisation is maintenance, repair and overhaul (MRO).[37] This was facilitated by the company's close support links in the rapid growth of the successful domestic airline, Singapore International Airlines (SIA). Indeed, ST Aerospace's support contracts for the rapidly growing SIA, facilitated its the former company's initial penetration into the commercial aerospace market in 1990 with the launch of its subsidiary, ST Aviation Services (SASCO).[38]

Fourthly, ST Aerospace's expansion was facilitated through a Japanese-type approach to technology development, pursuing a dual-use strategy to exploit market opportunities in both the military and commercial aerospace sectors.

Fifthly, ST Aerospace's growth was not constrained by the limited size of Singapore's domestic market. A feature of the business' growth strategy was that its customer base had become truly international as the quality and cost competitiveness of its outputs improved. Similarly, as the business expanded, so acquisition of relevant overseas businesses was undertaken, transforming ST Aerospace into a global aerospace operation.[39]

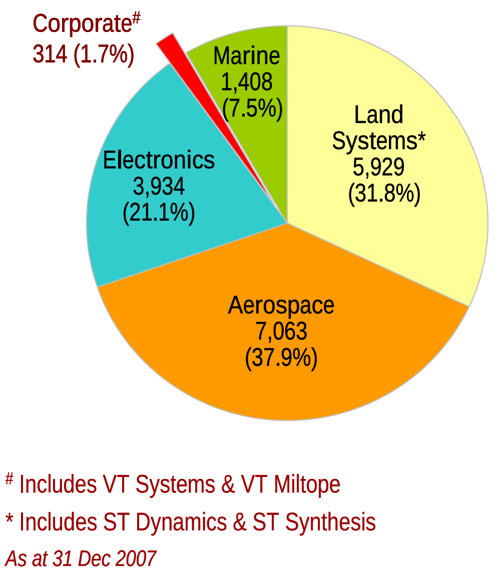
Finally, as this profile makes evident, ST Aerospace has never sought to develop and produce complete aircraft. The conglomerate's strategy was much more modest, focusing instead on the high value services associated with MRO, modification, upgrade and technology insertion.[40]

Although ST Aerospace has expanded its capabilities in mid-life upgrades, such as in the upgrade of Turkish F-5 combat aircraft with an Israeli corporate partner, aircraft conversion work, including, for instance, the conversion of a Boeing 767 passenger aircraft to a cargo plane, and manufacturing work, such as the rear fuselage for Eurocopter's EC120 helicopter, the Division's principal business focus is MRO and related services. Thus, ST Aerospace possesses 'total airframe' capability, with global operational capacity in such diverse places as Mobile and San Antonio in the US, Shanghai in China, and Panama in Central America.[41] This capability in the maintenance and modification of commercial airframes covers almost the entire product range of Airbus, DC, MD and the Boeing family of aircraft. There is also engineering and related development work, including design, re-engining, avionics design and upgrade and R&D work. Component and engine support is also provided, covering support activities for nearly all narrow-body aircraft engines, comprehensive support for all Royal Singapore Air Force military engines, with a capacity of 350 engines and 85,000 components through-put annually.[42] Again, as with airframing maintenance, and repair, engine total support has a global reach, including Scandinavia and China. ST Engineering's Fleet Management service offers engine maintenance based on a contemporary cost effective 'availability' support model; that is, maintenance-by-the-hour, as and when appropriate, ensuring that engines are always available to fly according to schedule.[43] On this basis, ST Aerospace has global support contracts on 450 engines and 600 aircraft under total component support (both engine and aircraft contracts serviced via a global network of partner companies across the world).[44] Due to the Division's emphasis on quality, reflected by certification to industry recognised standards, such a ISO9001 and ISO14001 and major civil aviation approvals, including FAA, EASA and CAAS, ST Aerospace has become, in a remarkably short period of time, the world's third biggest MRO company.[45]

ST Aerospace's rapid growth can be put down to a strong and visionary strategic plan and an emphasis on the development of human resources. As shown in Figure 3.4, the staff strength of the ST Engineering Group in 2008 numbered 18,648, with the Aerospace SBU registering the largest share of employment at 7,063.[46] The speed of the

Aerospace SBU's growth is reflected in the fact that its engineering labour force has increased by 55%, from 4,567 staff in 2001 to 7,063 in 2008.[47] The company places a high premium on training and skill enhancement, working closely with local

Figure 3.4: Staff Strength: ST Engineering Group



Source: Interview and Corporate presentation (21 August, 2008).

university engineering departments, For instance, ST Aerospace sponsors a scholarship programme at Nanyang Technological University for high-flying local engineering students.[48] Of course, the engineers within the business also necessarily undergo rigorous training programmes with overseas OEMs, such as Boeing, Airbus, Rolls-Royce and General Electric. Enhanced labour skills have enabled ST Aerospace to engage in work characterised by increasingly high value-added processes. Thus, the company has adopted a niche strategy of specialising in the innovative, high technology fields of systems integration, including the growth area of UAVs (Unmanned Aerial Vehicles), both in the civil and military sectors.[49] Linked to this high value engineering expertise is necessarily a corporate commitment to operate at the technological frontier. An important key performance indicator (KPI) in this regard is patent registrations: ST Aerospace having 12 filed and 10 granted.[50]

Much of the credit for the remarkable development of Singapore's aerospace industry must, of course, lie with ST Aerospace, its management and its workforce. However, one of the significant features of the Singaporean development 'model' is the interventionist support strategy of the government. Such support has played, and will continue to play, an important role in the development of the industry. In this respect, the government's Economic Development Board (EDB) has been instrumental in promoting a local high technology environment, conducive for the development of knowledge-intensive aerospace operations. Given the relatively high cost of Singapore qualified engineers, implicit in the EDB strategy is the need to encourage increased local aerospace skill-intensity to accommodate higher value innovational work programmes.[51] Thus, the EDB has economy-wide schemes for training local workers. There is a policy emphasis given to such schemes, not least because manufacturing in Singapore accounts for a high 25% of GDP.[52] Moreover, the prevailing policy view is that manufacturing drives the demand for services, which the EDB has been aggressively promoting.[53]

Within the manufacturing sector, ST Engineering is not only a major employer, at around 19,000 workers, but has enjoyed considerable output growth over recent decades.[54] Aerospace, for instance, has since 1990 experienced a compound growth of 10% in manufacturing output and 13% in 'nose-to-tail' MRO activities.[55] Aside from the institutional focus given to the upgrading of local engineering skills, the EDB for the past two decades has pursued a strategy of developing industrial and technological clusters.[56] Such clustering, both horizontally (competitor firms) and vertically (supplier firms), is held to maximise innovational endeavour through close proximity of constituent enterprise and access to a reservoir of appropriate skilled labour. Contemporary aerospace clusters in the UK, France and, indeed, China, also draw into the engineering network, local universities possessing specialist aerospace expertise. Singapore has similarly sought to promote local industrial clusters. A good example of this is the reclamation of land from several islands to condense into one island, located off the south-east coast of Singapore and called Jurong Island. The island houses a focused cluster of chemical and related downstream petro-chemical industries. There are other clusters focused on electronics, biotechnology and transportation, and also aerospace. The aerospace cluster is located at Selator, Western Singapore. The EDB is building up Selector as an aerospace park and it is planned that the park will eventually become home to many of the world's major aerospace companies. Whist it is possible to argue that Singapore, given its small size, is itself a cluster of high tech. industries, Singapore's EDB seeks to regionalize (within Singapore), by sectoral specialization, the various emerging industrial and knowledge clusters.[57] It has had much success in this regard, helped by the fact that Singapore attracts foreign investment because of the country's attractive, flexible, FDI regime. Singapore imposes no 'local content' requirements on MNCs investing in its local economy, and to ease their entry still further, foreign firms are offered generous assistance packages, including tax incentives, relocation assistance as well as subsidized schemes for the training local workers.[58]

Aside from ST aerospace relocating its MRO activities to Seletar, numerous specialist aerospace SMEs have also relocated. Moreover, other foreign MNCs that have sited factories, at Seletar,[59] include General Electric and Honeywell. One planned arrival is Rolls-Royce. This global aero-engine manufacturer plans to open an operation at Seletar focused on assembling the Rolls-Royce's Trent family of engines. The unit will be the first facility of its kind in Asia, and Rolls-Royce selected Singapore for the following reasons: the country has a dynamic business culture, possessing sophisticated skills and a global business outlook, (Singapore's trade, for instance, is three times its GDP); it possesses excellent engineering skills, and these come with high levels of productivity at relatively low cost; the knowledge-base is science and technology oriented; the government forms a key part of a tripartite relationship (including also business and trade unions) and has adopted a company-friendly business model, such that Singapore is characterised for its … 'ease of doing businesses'. This approach ensures that all stakeholders work together to achieve competitiveness with respect to both cost and quality, even during difficult times. Singapore also boasts a robust legal framework to protect IPR, and a far-sighted government that in 2004 designated technology-lead sectors as A*,[60] sponsoring their growth, and aiming by 2010 to have lifted Singapore's R&D to a new level of 3% of GDP.[61] All these factors influenced Rolls-Royce's decision to establish a major facility in Singapore, which will become its biggest MRO centre in Asia.[62] Moreover, importantly, Singapore's small size was irrelevant to Rolls-Royce reaching this decision.[63] A final contributory factor was Rolls-Royce's long successful business relationship with Singapore, stretching back to 1995. This was when Rolls-Royce won its biggest ever overseas order: Singapore International Airline's (SIA) acquisition of 60 Boeing 777 aircraft, powered by Rolls-Royce Trent 800 engines.[64] This required the British company to enter into a joint venture with SIA for Singapore-based MRO operations on its Trent Engines. This MRO base has now grown to be the biggest in the world for such engines, and Singapore $700m turnover has expanded so quickly that a huge expansion programme has now begun.[65]

Rolls-Royce views Singapore as its Asia business hub. The company places emphasis on technology partnerships, including those between SIA Engineering in Aero-engine repair and overhaul and the use of ST aerospace as a subcontractor in the manufacture of aero-engine components.[66] In addition to the Trent engine assembly operation, an Advanced Technology Centre (ATC) will also be established at Seletar. This follows an agreement with Singapore's Agency for Science, Technology and Research (A*STAR) and its Research Institutes. The work will cover a broad portfolio of technologies, but initially the focus will be on high performance computing for aerodynamic design, materials science and modeling for fuel cells.[67] Rolls-Royce offers scholarships on Nanyang Technological University's Aerospace Engineering degree and also works with the EDB for training, both locally and overseas, of its Singaporeans engineers and other professionals. As at 2008, no Rolls-Royce patents have been registered in Singapore.[68] But technology development is a long-term investment and critical mass is necessary. In 2008 Rolls-Royce employed nearly 2,000 staff, including 50 engineers at the embryonic ATC and 1,500 employees in the company's joint ventures.[69] It is planned that this number will double in the next three years.[70] The local business culture 'fits' Rolls-Royce's way of doing business, encouraging heavy investment at Seletar. By 2011, it is planned that the MRO operation will reach a through-put of 250 engines annually, requiring the testing of 20,000 parts prior to certification and return of the engines to Boeing and Airbus.[71] The MRO facility and the ATC are the first of their kind in Asia and fits into to Rolls-Royce's Global Strategic Plan to run the company in the future from London, New York and Singapore.[72]

3.3.3 Malaysia

The development of aerospace capacity in Malaysia goes back to the1970s, having its origins in the push for local defence industrialisation. Following Independence in the 1960s, the country's defence and aerospace requirements were sourced directly from abroad, most often from Britain. However, in the 1970s sovereignty issues started to gain a higher priority, and this naturally impacted firstly on defence capacity but later to linked commercial operations. For instance, the Aircraft Repair and Overhaul Depot (AIROD) was established in 1976 as a public sector enterprise to service Royal Malaysia Air Force (RMAF) aircraft. The major purpose of such investment was to create industrial capability to provide first-line logistical support to Malaysia's Armed Forces via through-life maintenance, repair and overhaul.

Development of domestic operational capacity really took off, however, in the 1990s. A major catalyst for the increase in investment in aerospace was the appointment of Dr Mahathir Mohamad, as Prime-Minster, and the 1991 publication of his Malaysia Vision 2020 policy.[73] This was a high-level plan to reorient Malaysia's economy away from labour-intensive industrial development, towards instead the development of high-technology sectors, particularly aerospace. The 'Vision' statement was aimed at accelerating Malaysian technological development, enabling the country to join the ranks of the advanced countries by 2020. Vision 2020 added to an existing number of government policy initiatives (including the New Economic Policy, Industrial Master Plan, the Five-year Plans and the Science and Technology Policy) to foster knowledge-intensive, high value, technology development in Malaysia.

The arrival of Dr Mahathir led to greater focus on Malaysia becoming a regional power, defined to include foreign policy, economic strength and military capability. Accordingly, the defence budget was increased, and a sizeable proportion of the spend allocated to supporting the emerging aerospace sector.[74] There was a policy view at the time that the procurement of military aircraft along with the associated technology offsets in components production and MRO, would ‘spin-off’ into related commercial aerospace areas to promote a local civil aerospace industry. This dual-use policy drove the creation of a Malaysian aerospace capacity-building programme. AIROD, for instance, as has already been mentioned, began operations in 1976, and was later incorporated as a private company in 1984 after merging with local-based Lockheed Aircraft Systems, finally becoming a fully-owned Malaysian company in 1995. In the mid-1980s, the company employed about 250 engineers, mostly former RMAF personnel.[75] In 2008, the workforce had grown to over 1,200 qualified and experienced engineers.[76] Whilst AIROD remains essentially a defence aerospace company, it represents the bedrock, along with a few other major aerospace enterprises, of Malaysia’s emerging aviation industry. The development of these other primarily commercial aviation firms will be examined in more detail, below.

One of these commercial aviation businesses is SME Aerospace (SMEA). The company began operations in 1990, formed through an offsets venture with BAE to produce weapons pythons for the then recently purchased Hawk Fighter.[77] Since that time, SMEA has built-up its capacity and diversified its product range to produce aircraft parts, components and subassemblies, integrated into BAE systems’ global military and civil supply chain. SMEA continues to supply Hawk pylons; indeed, is the principal supplier, having consolidated its manufacturing capability through investments in extra tooling, and laboratory and testing equipment. This is, therefore, an example of a successful offsets programme, where all subsequent pylon contracts have been won by SME through competition.[78] Product quality was a given; it was competitive pricing that secured the contracts.[79] There are 426 parts on each pylon, and whilst SMEA engineers have provided training to Indian Hawk engineers, both in Kuala Lumpur and Bangalore, the Indians have as yet been unable to absorb the technology requirements.[80] SMEA now supplies pylons for integration into the 66 Hawk fighter/trainers India has recently purchased from Britain.[81] In fact, these sales represent a portion of SMEA’s pylon output, which is in 100% export driven.[82] In addition to the 24 sets of pylons delivered to India, SMEA also currently has supply contracts with South Africa, Australia and Bahrain.[83] The work is skill-based fabrication with thus little in the way of a supply chain as only steel is required, and this is imported from overseas suppliers. The CNC cutting machine tools are locally sourced, with approval required from BAES, Remarkably, SMEA's strategy is to remain focused on this relatively low-value fabrication activity. The alternative of moving into high technology areas of specialization is not appealing to the company, due to the competitive niche that the company finds itself, and the aversion to risk that higher technology activities would impose.[84] Thus, SMEA has no design office, no design teams, as graduates are expensive, and the designers previously employed on the now terminated 'national' MD3 aircraft project have migrated to CTRM, another Malaysian aerospace company.[85] This labour–intensive emphasis on metal machining and fabrication rather than component manufacture keeps technology low, but also keeps cost structures low. SMEA does not use graduates, but rather technicians from local schools are employed and inhouse trained in the basic skills. Moreover, some 80 low-cost, but skilled, Indonesian workers currently form part of the company's 600 strong workforce.[86] This employee total shows a rapid increase over the 100 workers employed in 1991.[87] A major reason for this growth in labour has, of course, been the company's expansion in activities.

In the past, SMEA had ventured into aircraft production, including such projects as the MD3, and a later programme to build the Eagle aircraft which was terminated in 2005. It seems that local aircraft production in Malaysia has proved too difficult to make money.[88] So the strategy, as earlier mentioned, was to focus on fabrication, and whilst the introduction of CNC machining reduces maintenance (as the metal part is no longer the product of several welding operations but is rather a whole unified part), it does not mean that sheet metal fabrication will disappear. Thus, SMEA supplies trailing edges, sub-spar assemblies and aft pylon fairings for the Airbus A320 and A340 aircraft, as well as vertical horizontal fins for helicopters.[89] SMEA also specializes in work packages for aircraft conversion, such as the transformation of 15-20 year old Boeing 747s into cargo aircraft. Here, the company supplies metal kits to Boeing, which then ships them to ST Aerospace, Singapore, for conversion work on ageing Boeing airliners. Such kits are also supplied to Boeing for onward shipment to its conversion facility in Xiamen, China. The kits are not produced in China because Chinese aerospace/aviation factories are state-owned and thus production costs are higher than those of SMEA.[90]

Composites Technology Research Malaysia (CTRM) is another leading Malaysian aerospace company. It incorporation in 1991 was driven by the Vision 2020 government plan that aimed to target the development of aerospace as a strategic industry. In the early 1990s, the company specialized in the design and production of aircraft parts as well as the leasing and sourcing of aircraft through its subsidiary companies. By 2008, CTRM had diversified into composite design, manufacturing and assembly of non-aerospace industry, particularly in automotive, defence and industrial products.[91] However, the principal focus remains on aerospace. The CRTM group of companies (Aviation, Aero composite, Composites Engineering, and Unmanned Systems Technology) is 90% Ministry of Finance owned and 10% owned by Malaysian energy company, Petronas.[92]

The initial 1990's production focus of CTRM was on the manufacture of hockey sticks.[93] The unique feature of this product was that they were made from composite materials. Composites were also used to produce cargo containers, centrifuges for medical purposes, and reinforced structures. At the same time CTRM personnel were stationed in Perth, Australia, after acquiring the Eagle Australia aircraft production facility. A particular benefit of this project was the Malaysian's acquisition of technical know-how and composite manufacturing skills. In the mid-1990s, the production of the Eagle aircraft was relocated to CRTM's Malacca plant, gaining certification by the FAA in 1999. Also, during this period, the company teamed-up with Lancair to gain further technical know-how. Growth in global composites subcontract work occurred in the early years of this century. CTRM won composite contracts for the A300 fixed trailing edge, the A320 leading and trailing edges (46 components), seven further work packages for the A320, and became the first Asian partner for A380 design and manufacturing work.[94] The rapid expansion of work for Airbus meant that CRTM quietly became its 15th biggest airframe supplier, the 5th biggest in composites, and biggest for Airbus UK (prior to the UK's withdrawal from the Airbus consortium, with much of the work being taken over by Spirit Aero structures (Europe).[95] More diversified subcontract work also came CTRM’s way. This included composites contracts on the European Heavy lift A400M military aircraft. Nacelle work on the V2500 and Boeing 787 engine cowlings, production of Lotus Europa automobile body panels, Boeing 787 composites contracts and major contracts with the Malaysian MINDEF, including Radome’s for the Malaysian Air force and Unmanned Aerial Vehicles in the civil and military sectors.[96]

CTRM growth in its diversified product portfolio has led to a near four-fold increase in its workforce, from 393 staff in 2001 to 1,196 in 2008.[97] Going further back in time, there were just 79 workers in 1999 and managerial staff numbered below 10 when the firm started operations in 1991.[98] The Senior General Manager, Mr. Zulkarnain Mohamed puts CRTM’s success down to ‘ACD’ (Quality, Cost and Delivery).[99] The aim has always been to achieve high levels of competitiveness through the development of a business culture based on trust and partnership. Competitive success can be seen by CTRM’s growth in sales revenue from Ringgit 34m to over Ringgit 300m growth in 2008.[100] Remarkably, for a government-owned company, success has been achieved without using government funding. Only commercial finance has been used to run the business. Furthermore, none of the contracts awarded has been via offsets. Instead, international business has been won on a competitive basis.[101] Thus, CTRM won the A380 and A400M contracts partially because it has proved itself as a capable high quality supplier on the BAES, Boeing, Airbus and other global aviation production programmes.

CTRM’s business requires highly skilled composites engineers. Much of their training is conducted inhouse, though there is no company training school. Some workers do attend local vocational colleges and, additionally, internships, and up to 10 scholarships are offered annually to students at the University of Technology, Malaysia. Often, foreign OEMs require CTRM staff to attend specialist training programmes overseas. For instance, Goodrich, a US contractor on the global V2500 aero-engine programme, required CTRM staff to attend a US two week training course to teach best practice manufacturing concepts.[102] Finally, in collaboration with Airbus, CTRM has established a small R&D centre, staffed by five qualified engineers. The R&D spend against sales revenue is currently 1%.[103] This is a modest investment, but the senior management has plans to register patents, in the future.[104]

The final major commercial aviation company located in Malaysia is the Kuala Lumpur-based helicopter manufacturer, Eurocopter. This is a French-Spanish-German operation that has over 20 assembly plants worldwide, claiming to be the world's biggest producer of helicopters.[105] Eurocopter's successful growth strategy has been based on the supply and subsequent buyback of helicopters from customers that then benefit by a new rotary aircraft replacement programme. This forms part of an aggressive market penetration strategy focusing on capturing high market share through competitive pricing structures. The consequence of this approach is a positive, but low 2% (earnings before interest and tax) return on a Euro 18bn turnover.[106]

Eurocopter Malaysia is a Southeast Asian symbolisation of Eurocopter's global growth strategy. The Malaysian operation began in 2004 through a defence offset programme linked to Kuala Lumpur's procurement of six Fennec military helicopters. The Eurocopter facility concentrates on MRO work across the broad range of its helicopters. Eurocopter corporate is not interested in MRO work and is content to transfer such capacity to regional subsidiaries, such as its Malaysia operation.[107] There is some manufacturing, limited to the supply of around 60 components for EC135 helicopter production overseas. For MRO and subcontract production work, Eurocopter has developed a supply chain of some 17 Malaysian firms.[108] These include CTRM and Itramatik, involving purchases of metals, composites, wiring and training simulation. As at 2008, there was no R&D investment and no design facility.[109] For some essential testing services, Eurocopter outsources the work. For instance, wind tunnel tasks are subcontracted to the University of Technology Malaysia's research facility at Johor Bahru.[110]

Employee training is given a high priority because contracts are highly competitive, requiring high levels of productivity including maintenance provisions specifying that payments are disallowed if helicopters do not fly. There is a training school, but it runs on an *ad hoc* basis, offering courses, as and when. Each Eurocopter approved course will accommodate approximately 25 Malaysian trainee staff.[111] There will also be on-the-job training given for specific tasks, and, additionally, selected skilled workers will go to France for specialist training. Finally, Eurocopter Malaysia runs a one-year internship programme. Since 2005, the firm has offered 50 internships to engineering graduates from Malaysian universities.[112] The track record of job offers to internees, following the ending of their internships, has been the employment of at least two Malaysian graduate design engineering positions annually, amounting to a total hiring by end-2008 of 15 internees.[113]

Other global OEMs have a marketing presence in Malaysia, but no manufacturing and no MRO operations. Agusta-Westland, for instance, is Eurocopter's major competitor in the helicopter field. The Italian-owned company is reluctant to invest in Malaysia. Presently, there are no incentives for long-term investment in the country: pre-banking of offset credits is not allowed,[114] and the big disincentive for OEMs is that Ministry of Finance regulators insist on only short-term, normally one year contracts, to encourage local companies to participate in the supply of work.[115] Moreover, a major problem in Malaysia's aviation business is the lack of transparency, where communication and availability of information is limited, thus increasing the importance of local connections. Notwithstanding the challenges of Malaysia's business environment, Agusta-Westland has a team of 15 staff in the country. Whilst most of the company's civil and military airframes are produced in Poland, due to low labour cost, there are plans to set-up a MRO capacity in Malaysia, and possible also to offer training through the establishment of a joint-venture with a local company.[116] Agusta-Westland's cautious approach to FDI in Malaysia is based on the weak business case and acquisition volumes that do not justify offset investment and the creation of local capacity. With just single-digit 'helo' sales to the fire service and navy, the small production runs carry a level of business risk that is too high in the short-term Malaysian contractual environment.[117]

Aside from Augsta-Westland, the other major OEM with a sizeable presence in Malaysia is BAES. The British company until quite recently had a major in-country commercial aviation focus through its participation in Airbus industries. It continues to act as a subcontractor on the Airbus programme, but has increasingly shifted its attention to military aerospace ventures. BAES has had considerable success in the Malaysian aviation market and this has been recognized by the Malaysian authorities.[118] BAES argues that it has regularly outsourced work packages to Malaysian aerospace companies, including AIROD, SMEA and CTRM; indeed, without BAES offsets, CTRM would unlikely have begun operations.[119] However, as with Agusta–Westland, BAES, needs to have a clear business case for transferring technology into Malaysia, rather than the current practise of outsourcing work to Malaysian subcontractors. Either way, the need for viable and sustainable business opportunities is essential for an effective long-term relationship to develop. The BAES team in Malaysia has worked hard to achieve this goal, putting down its ‘perceived’ success to patience, a commitment to creating real partnerships, transparency, plenty of people on the ground, and most of all time.[120]

Finally, from a macro perspective, the Malaysian Government established in 1993 a centralised public sector organisation to support technological development. It is called the Malaysian Industry-Government Group for High Technology (MIGHT) and whilst having a more focused technological objective, it operates according to the same goals and processes as Singapore Economic Development Board. As with EDB, Malaysia's MIGHT has developed policies to promote development of a local aviation sector. The starting point was 2001 when the Malaysian Aerospace Council was created to promote investment, employment training and productive expansion in the following areas: MRO; parts component manufacture; systems integration; and aerospace training and education.[121] A partial aerospace strategy has been developed that aims to direct effort and resources towards three key strategic goals: technology innovation; cost-effectiveness; and the development of ‘indigenous’ manufacturing capacity.[122] Special incentives have been introduced through the 'Industry Investment Act' to encourage investment aviation-related MRO and manufacturing activities. A principal feature of these incentives is tax concessions, including tax holidays and investment relief. These policies have had some success, with for instance, Malaysia Airlines' 30% joint venture with Honeywell Aerospace Services (M) Sdn Bhd and GE Engine Services Malaysia Sdn Bhd, but the volume of foreign OEM entry into the Malaysia aviation sector, to date, has been limited.[123] Thus, overall, whilst Malaysian aviation sales have grown impressively, reaching Ringgit 24bn in 2007, the sector's industrial 'depth' remains shallow.[124] A sense of this is gained by the fact that local contribution to value added is a lowly 1%, indicating a focus on low skill, labour -intensive activities rather than on research, design and development capabilities.[125]

3.3.4 South Korea

South Korea began aircraft production in the late 1970s with production of 500 MD helicopters under a license agreement with McDonnell Douglas of the US However, South Korea’s aerospace development push really only began with the government's 1999 decision to consolidate the three major aerospace companies into what was called Korean Aerospace Industries Ltd. (KAI).[126] This newly formed aerospace entity comprised Samsung Aerospace, Daewoo Heavy Industries and Hyundai Space and Aircraft Company. The government granted KAI special privileges. To begin, KAI was given exclusive rights for all the government's military logistics and aerospace projects, designating KAI as an ...“exclusive business organization for the Korean Aerospace Industry”... and also as a …“specialized company for the Korea Aerospace Industry.”[127] Thirdly, the government further agreed to provide 50% of the total development cost of any commercial aerospace project.[128] In 2000, KAI embarked on a focused R&D programme working in partnership with Korea's Agency for Defense Development, the Korea Aerospace Research Institute and the Defense Quality Assurance Agency.

However, since 1999, South Korea’s aerospace sector has been dominated by defence activities. Aside from the 500 MD helicopters, the F5E/F, F-16k and F-15 fighters have all been license-produced in big numbers. Additionally, a further helicopter license-production programme commenced, focusing on the more sophisticated American UH-60 rotary aircraft. Moreover, over recent times, progress has been made in the development of indigenous aircraft. This is reflected by the successful launch of the KT-1 piston-propeller type basic trainer and also the advanced jet trainer T-50; the latter being jointly developed with Lockheed Martin and looking remarkably similar to the silhouette of the US F-16 aircraft. The commercial side of KAI’s operations, by comparison, is modest. KAI and Korea Air have participated in commercial business areas through large commercial airline work programmes, including, for instance, the Boeing 787 and the Airbus A350.[129] Overall, the Korean aircraft industry has grown rapidly over the last decade. In 2007, the production of Korean aircraft reached around US$1.5bn and exports of US$300mn.[130] In 2004, Korea ranked eleventh in global aerospace manufacturing capacity, and is aiming to achieve sixth place by 2012, supported by Korean government aerospace industrial support.[131] South Korean's aerospace industrial strategy has assisted this development process by supporting 1) systems assembly under license agreements with foreign advanced companies: this being followed by 2) airframe parts and subassembly manufacturing; 3) sub-assembly development; and 4) systems development via indigenous capabilities.

3.3.5 Indonesia's Aerospace Dream

The home of Indonesia's aerospace industry is Bandung. Production began in 1976 with the establishment of the state-owned company, PT IPTN. Dr Habibie, the then Minister of Technology, viewed PT IPTN as one of the key 'strategic' industries that would support the development of civil and military aerospace related industries in Indonesia. Demand through the build-up of the Indonesian air Force and national airline, Garuda, would promote local aeronautical engineering skills and capacity. Work would go to the PT IPTN operation via offset contracts. In fact, the contractual arrangement proved successful and on the Boeing commercial programmes. PT IPTN became part of the US OEM's global supply chain, with Indonesian produced components being shipped to Mitsubishi, Japan, to be integrated into higher value subassemblies, for onward shipment to Seattle and integration into Boeing's final assembly operations.[132] PT IPTN also benefitted from production work on the locally produced CN235 military transport/civil passenger aircraft through its joint venture with CASA of Spain. Additionally, there was commercial work through offsets with Airbus, Eurocopter and Bell Helicopters. Defence offsets work was also evident through F-16 contracts with the US producer, General Dynamics.[133]

The 1997-8 Asian-Pacific economic and financial crisis led to a relative decline of PT IPTN's operations. The IMF in its US$50bn loan conditions forced the Jakarta government to remove the PT IPTN subsidy, and, as a consequence, in the years that followed, the company suffered a long-term contraction of capacity. What made the situation worse was the government's ideological switch to right-wing liberalist policies, whereby competitive pressures became the major policy thrust for developing Indonesia's aerospace sector. The policy emphasis on 'competition' was in line with not only IMF policy, but also the general economic thinking of the late 1990s and into the new century. This might not have been a problem, if the government through its aircraft purchases had worked to sustain PT IPTN aerospace capacity, but its procurement approach, based on 'open-competition', ensured that aircraft orders went to overseas suppliers, with no requirement for offset work to be channeled into the PT IPTN Bandung complex.[134]

The consequence of a competition-led business environment has been that the Indonesian aerospace sector has struggled. Its position has been made worse by MINDEF's 2006-8 defence doctrine of Minimum Essential Force, caused by 'affordability' pressures, institutionalising Indonesia's Air Force to a minimum level of aircraft inventory. The aircraft industry in Bandung has responded to these difficult conditions by seeking to re-brand itself, changing its name from PT IPTN to PT Dirgantara (PT DI). However, aircraft production volumes remain low, over the past three years there have been just four sales of CN-235 aircraft to the Indonesian Navy, around 20 to Iran, and just the prospect of sales, to Bangladesh.[135] The business focus has instead been on MRO work, and diversification into surveillance aircraft and simulators.[136] The government has stated that it will not allow PT DI to collapse, but the problem according to a senior PT DI director is that…"the government does not understand the aerospace industry."[137] There appears urgency to the problems that PT DI faces, reflected in the dramatic reductions of the company's workforce. In 2003, 6,600 employees were retrenched, reducing levels to around 3,300 from over 9,000 previously employed.[138] By 2008, employment had risen slightly to 3,700 due to the scale of maintenance work and other diversified work in such areas as precision tooling for Mitsubishi hovercraft and simulator equipment.[139] The paradox of PT DI is that, whilst the company struggles to maintain its aviation profile with the Indonesian government, at the same time, it has developed an international reputation as a quality aviation parts supplier to Western OEMs. For example, PT DI produces level II components for the Airbus A380, A340 and A320 aircraft, including a contract to produce 18 components per leading edge for the A380, amounting to 300 sets on a contract expiring in 2014.[140] There also continues to be composite work on the rear tail fins of USAF F-16 combat aircraft.[141] Other aviation work is undertaken for Boeing and Eurocopter. Moreover, in the composites area, PT DI works as a subcontractor for the Malaysian firm, CTRM.[142] Importantly, all these aviation contracts have been won on a competitive basis, and none involve offsets deals.[143] Success in competitive tending also extends to the military field, where PT DI has recently won a contract on the EADS A400M programme for systems design, adaption and flight dynamics.[144] PT DI possesses capability in aircraft design, wing structures and engineering services. It is also working on a small 20-seat aircraft, the C312, a licensed production for CASA.[145] Yet, there is limited capital available for development investment. Even so, the company is committed to product development and allocates 10% of its profit to R&D, but profit is probably small.[146] There is a training school for college-level engineering trainees, but aerospace skills continue to be lost, with skilled workers being transferred from aircraft production to hovercraft and 'Flying School' diversification ventures.[147]

Thus, while PT DI is able to demonstrate high levels of competence in its subcontract activities with foreign OEMs, it faces many challenges in developing its indigenous aerospace production capabilities. It is a strategic industry, but in reality this has no meaning. There is no protection and no government support.[148] Nearly all material must be imported, including composite materials (kevlar, fibre glass and carbon fibre).[149] The company is saddled with big debts owed to the government on a failed local project, the N250 aircraft, with no possibility of paying off these debts.[150] There are also difficulties in the long-run in terms of evolving an international 'brand', and in the short-run, with the challenge of managing adverse movements in the US$: Rupiah exchange rate.[151] Moreover, a local supply chain has not been created, such that whilst PI DI has over 500 general (civil) suppliers from the local economy, a high value added network of SMEs has not yet been formed.[152] Finally, although the government is procuring at least six Russian SU-30 fighter aircraft, the Russians have provided credit for this procurement, but no offset work has been agreed for the Bandung aerospace complex.[153] So even though President Susilo Bambang Yudhoyono, stated in 2009 that Indonesia's defence/aerospace sector will be supported, industry lacks confidence that a supportive policy will be introduced.[154]

3.4 Summary

The analysis in Chapter 3 has sought to provide a regional contextual backdrop to the China case study analysis of general industrial development and focused aviation development to be undertaken in, respectively, chapters 4 and 5. Such a comparative analysis will assist in benchmarking China's industrial and technology progress to that achieved by other latecomer Asian economies. This is interesting for two reasons. Firstly, given that all countries face the same problems (and benefits), a comparative analysis will highlight relative success stories with respect to capacity creation and, if possible, indigenous development. However, it is helpful to highlight not only development successes but also the failures. Importantly such analysis may reveal differences in policy approach, factors conditions and micro and macro strategy.

The second reason why a comparative appraisal of Asian aviation activities is a useful exercise is because the original Akamatsu Flying Geese Model did not take into consideration the possibility that China would one day form part of an integrated Asian model. So, in this sense, the inclusion of China (Chapter 6) into this study's evaluation of NICs and ASEAN4 aviation manufacturing company performance increases the realism of the flying geese study methodology. Since the 2nd batch of Akamatsu's writings was published in the 1960, China has evolved, slowly at first, but then rapidly, as an industrializing country. Reflecting on this growth, it is possible that China may have ‘broken the mould’ in overcoming many of the challenges Asian countries face in developing aerospace capacity, but this investigation will be left to Chapter 5.

A factor common to all Asian countries pursuing aviation activities is that the diffusion of technology comes not from Japan, but rather from the US and Europe. In this respect, Akamatsu, did not conceptualise the impact that globalisation would have on developing country economies, particularly on trade and MNC investment patterns. Globalisation has acted to break-down many of the barriers to trade that previously existed. It also means that if markets are sufficiently attractive to the (MNC) OEMs then the latter will go 'directly' to particular Asian markets and negotiate deals: market entry for technology access.

Thus, this chapter offers findings from empirical study of commercial aviation development in selected Asian countries. Amongst the NICs only South Korea has developed an aerospace capacity, but fieldwork in Korea was not undertaken because commercial aerospace forms a tiny proportion of overall Korean aerospace manufacturing capacity; the majority of investment being channeled into the military aerospace sector. Japan was also not included in the empirical fieldwork of Asian aviation companies. Approaches to Japanese companies were made, and in particular to Mitsubishi, but it appears that the author’s Chinese citizenship and Japan's sensitivity to aerospace activities meant that the invitation to visit Japanese aviation plants was not forthcoming.

A profile of the companies included in the Asia fieldwork is shown at Table 3.1. The results of the fieldwork and desk research are mixed, as detailed in Table 3.1. Only Indonesia of the countries surveyed has developed capacity to produce airliners. Japan and Malaysia have tried but failed, and Singapore and South Korea have deliberately specialised in the provision of services, MRO and spares. Japan has recently announced plans to renew it attempts to design and develop a commercial passenger aircraft, but scale limitations have deterred the ambitions of other countries.

All the Asian companies surveyed have developed capacity through collaborative contracts with foreign OEMs. In many cases, work was first sourced through offset deals. Once the skills and capacity had been created then 'spin-off' work in the commercial area was begun. Over a longer period, this was also probably the case for the Japanese aerospace companies, which are dual-use in nature. However, at different levels of technological sophistication, all countries were constrained by the difficulties of technology access. On the one hand, overseas aerospace contractors were reluctant to release technology, and on the other, local efforts suffered because of minimal R&D expenditure. Although not producing aircraft, Singapore and Japan, have benefited from high volume and high technological quality of work via specialisation on MRO

Table 3.1: Asia Aviation Industry Survey: Company Profiles

		Singapore		Malaysia			Indonesia
		ST Aerospace	Rolls-Royce,	SME	CTRM	Eurocopter	PT Dirgantara
Company Profile	**Year of Establishment**	1975	1995	1993	1991	2002	1976
	Ownership Type	Temasek 50.8% Public 49.2%	UK, PLC	Private Limited	Private Limited	full foreign-owned	owned by the government of Indonesia
	Employment (2007)	7,491	1000	592	1196	133	3,720
	Business Focus	MRO, Conversion mid-life upgrades	Engine, MRO	Production of parts & components for civil, military, fixed wing and rotary aircraft	Composites	MRO	aircraft design, development and manufacturing of civilian (and military) regional and commuter aircraft
	Output Value (2008)	S$1,838mn (US$1248.6mn)	n/a	RM76mn (US$21.7mn)	RM297mn (US$84.9)	US$46.9mn	n/a
Skill Generation	**Company Training School**	Technical Training Centre	nil	nil	nil	yes	nil
R&D	**Possession of R&D facility**	(450 technical staff)	nil	nil	nil	small design office	nil
	R&D spend (US$2008)	2.5% of sales	nil	nil	nil	US$45,000	nil
	Patents	12 filed; 10 granted	nil	nil	negligible	nil	nil
Local Supply Chain	**Number of subcontractors**	OEMs plus 20 certified local vendors	few	4	5 for metals and tooling	5	nil

Source: Author, abstracted from various primary and secondary sources activities and high technology components and subassemblies, respectively. Thus, while Singapore and Japan have enjoyed relatively higher value added production, generally for Malaysia and Indonesia, this has not been the case.

All companies surveyed placed a premium on skill enhancement and training. Yet, there were variances in company approaches. The global OEMs, such as Rolls-Royce, were drawn to Singapore, because of highly skilled local engineering labour. Rolls-Royces' strategy has been to exploit these resources, short-term, and to enhance them through high tech training centres, long-term. ST Aerospace has placed a similar premium on efforts to up-skill its aeronautical engineers, By contrast, Malaysian and Indonesian aviation companies, whilst recognizing the importance of human capital investment, in reality provide training through 'sitting with Nellie' on the shop floor and *ad hoc* basic inhouse courses via cooperation with local colleges. Eurocopter (Malaysia) has gone beyond this, however, through promoting design skills in partnered university internship programmes. Graduate intake into the aerospace companies was limited. University specialisation in aerospace existed, but only at low levels of expertise. The exception appears to be in Singapore, where ST Aerospace works closely with local universities along with the OEM companies established in the country. BAES in Malaysia has also been keen to invest in the local university sector. Through discussions in the field, it seems that the technical level of training and education was kept low by the 'undemanding' nature of the aviation production work. For instance, one Malaysian company maintained a full order book by focusing on low value-added machining and fabrication of simple structures. This production niche was unattractive to the overseas' OEM, but profitable to the Malaysian company.

R&D in nearly all the Asian companies surveyed was minimal, if not non-existent. R&D was viewed as important, but not affordable given the low volumes of work along with the focus on services rather than manufacturing. No evidence of patents was discovered during the fieldwork, except in the case of ST Aerospace, where innovation was likely driven by incompany technological synergies (skills pooled across the complementary divisions within the company). Patents, however, are often an expression of corporate institutionalised investment. Within a company, such innovation is likely to be the result of formal R&D investment, but innovational benefits may occur outside the business in less formal ways from relationships with suppliers.

The industrial advantages gained from working with local suppliers were known to all the Asian aviation companies visited, but for Malaysia and Indonesia, local specialist supply chains had not developed. By contrast, as in other fields, Singapore had developed extensive plans to promote local high technology clusters, a policy move the government was supporting. As was emphasized in Chapter 2, subcontractors cannot be created overnight, and the one essential ingredient is sufficient demand, but in Malaysia and Indonesia, this had not been achieved.

In summary, then, it would appear that Singapore, like Japan, has been successful in developing aviation capacity, because of the focus on a long-term government strategy. The creation of sufficient demand through emphasis on quality and cost, ie competitiveness, focused on niche services and/or manufacture. Singapore's success is also symbolic of its emphasis on human capital investment, and upgraded skills often correlate with innovation and technological development. Singapore’s focus on the need to promote industrial clustering of local and also foreign high technology aerospace engineering companies provides further evidence of Singapore's institutional and corporate commitment to local aviation development.

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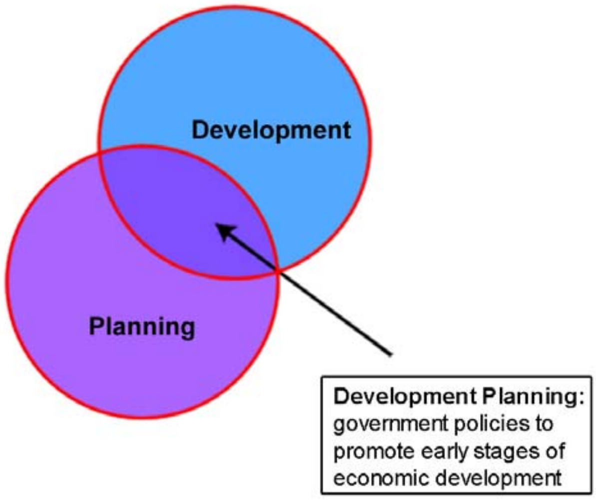
Chapter 4 China's Economic Transformation and the Emergence of a Fledgling Aviation Industry

4.1 DEVELOPMENT PLANNING: The Crisis of China's Command Economy, 1949-79

The purpose of this chapter is to explore China's broad-based development planning approach; the first of the three macro-level development and planning processes, outlined in Figure 2.10. The relation between development and planning is illustrated in Figure 4.1 below, and highlights the need for government strategy to foster high levels of economic growth to effect sustainable development. From the beginning, the central thrust of government policy was to promote transition from an agrarian economy to an industrial model. Rapid diversification would be achieved through a fast pace of industrialisation, and facilitated by foreign direct investment.

Figure 4.1: Development Planning



Source: Author, abstracted from Figure 2.10.

The focus of this chapter is on the development of modern China, but there is a question as to when modern China, along with its modern industries, began to evolve. The aviation industry is to all extents and purposes a post-WW II development phenomenon, and, indeed, this will represent the time-parameters, here; however, it is appropriate to note that modern China's industrial and technological progress was cast by the profound historical events that occurred centuries prior to the 20th century. To some extent, major influences on China's development trajectory happened during the 16th and 17th centuries. This was when China began to be exposed to European influences and religious pursuits though the arrival of scholars, explorers and missionaries. In particular, it is said that the Jesuits introduced the Western sciences of astronomy, mathematics, geography, cartography and architecture.[1] Equally, through, the Opium War of the later 1830s represents an important milestone in China's development. This 'cataclysmic' event was the point of departure for the ensuing century of foreign imperialism, subjugation and impoverishment of the Chinese people.[2] The war kick-started not only the immediate overseas scramble for ownership of China's vast untapped resources, but set the scene for the 20th century Marxist economic revolution as a reaction to colonial exploitation.

Foreign influence really only began to impact on China's economy after the Opium War, following the rise in port trade, the demise of Manzu power, and coincidental with military modernisation and the beginnings of industrialisation. Whilst imperialist influence retarded local innovation and scientific development, growth and development of the China's business community was not deterred. By contrast, the first half of the 20th century witnessed the ideological awakening of China. Ideological fermentation was viewed as a vehicle for nationalism and reunification. However, it had the opposite effect, engendering almost continuous conflict: the KMT-CCT conflict;[3] the civil war of 1946-1949, and, whilst divorced from China's internal policies, there was, of course, the bloody Sino-Japanese war 1937-1945, with all these wars having an identical negative impact on the vitality of China's economy.

A similar story of chaotic, uncertain and contradictory development planning, occurred after the People's Republic was established in 1949. Wild and unpredictable swings in policy occurred from, for instance, the early, warm, strategic and economic Sino-Soviet socialist embrace, to the 'Four Modernisations', then onward transition to the building of Socialism with Chinese characteristics (*Zhongguo Tese De Shehui Zhuyi*,中国特色的社会主义) and, finally, to the contemporary policy, evolved from Deng Xiaoping's unique Market-Socialism ‘model’ of development.[4] The process of accelerated FDI only really took-off, post-1979 following Deng Xiaoping’s open-door policy, but any study of modern China’s industrial and technological progress would be flawed in the absence of a contextual understanding of the historical building block shaping China’s economic, cultural and governmental development. Moreover, it is important to note that China’s tortuous development journey did not occur in isolation from its Asian neighbours. Nearly all the countries in the Far East suffered at the hands of the colonialists and in similarity with China, suffered from a lack of local business autonomy, low levels of innovation and limited domestic skill enhancement. The purpose of this chapter, then, is to review the regional context, identify the economic challenges and development planning responses of the Far Eastern States before focusing on the study of China seeking industrialization via the technology transfer mechanism of FDI.

4.1.1 Asia’s Evolving Dynamic Comparative Advantage

Over the early post WWII period, large number of formerly colonised Asian nations sought independence. India was one of the first and the biggest to enjoy independent rule (1947), and its path to independence was relatively peaceful. Vietnam, by contrast, suffered a long and painful extraction from foreign colonial rule. The ravages of the Second World War through Japanese aggression changed forever the political and nationalist landscape in the Far East. Oppression would no longer be tolerated, and a whole swathe of countries, covering Indonesia, South Korea, the Philippines and later Malaysia and Singapore, obtained political and economic sovereignty.

Economic self-reliance was an important part of the package. No country could be independent unless it achieved economic self-reliance. For some Asia countries, the goal of self-sufficiency is as true today as it was in the 1950/60s. Even in an era of rapid globalisation, the driver for economic nationalism and industrial sovereignty is a policy beacon that continues to shine brightly. India, China, the Koreas, and Japan, are all countries possessing sufficient internal demand to make feasible such a goal. Yet whilst most countries in Asia, including China, pursued similar development planning models, emphasising necessarily the strategy of import-substitution, the development impact across countries differed wildly. China, as will be detailed later in this chapter, veered chaotically from a heavy engineering development embrace with the Soviets, to balanced agricultural development (walking on two legs - *Liang Tiao Tui Zoulu* 两条腿走路), to finally, balanced development policies, incorporating the intellectually destructive Cultural Revolution (*Wenhua Da Geming* 文化大革命). Similarly, India, with an equally huge internal 'pent-up' demand, aggressively import-substituted foreign products with home-grown manufactured goods. However, New Delhi put in place inflexible and highly bureaucratic planning approaches that stifled local innovation and productive efficiency. Import-substitution promoted Indian production, but that was all, and few, if any industrial comparative advantages evolved, irrespective of the low labour cost benefits enjoyed by Indian manufacturers. In the Indian case, import-substitution strategy, begun in 1951 at the time of the country's First Five-Year Plan, was a failure. Manufacturing capacity was created through technology access from foreign collaborators, but the lack of competitive and innovational dynamism meant Indian firms continued to depend on foreign suppliers for the next generation of technology design. It was only after economic liberation in 1992, and, the subsequent push towards export production, that the Subcontinent's economic development finally began to make real progress.

During the initial development phase, newly independent Asian countries all mostly followed the import-substitution development planning process. For the small states, however, this was of limited duration because of the urgent need to achieve a critical mass of sustainable demand. Thus, for Singapore, Malaysia, and even Taiwan and South Korea, the push for Rostow's economic take-off was pursued via export-driven basic manufacturing industries, including toys, cycles and simple electronic goods. With the passage of time, specialisation evolved in computer goods, microelectronic parts and consumer durables, such as TVs and radios. In the process, skills were raised, local production promoted, and, through trading links with overseas Original Equipment Manufacturers (OEMs), opportunities for assembly production in key re-export fields were exploited.

The lead country at the head of this Asia-Pacific development push was, remarkably, Japan. It was remarkable, because the Japanese economy had been more or less destroyed by US bombing in 1945. However, the skill-base was intact, and hence surprisingly quickly in the 1950s, and beyond, the Japanese authorities successfully transformed their industrial focus away from a war economy towards commercial production. To begin, the policy thrust emphasised technology access through learning of foreign technologies rather than FDI. The Japanese development model was characterised by its dependence on 'copying' rather than original design. Due to export production, though, Japanese industry succeeded or achieving scale and thus a competitive unit production cost. Japan's development model was dynamic, moving to higher levels of technology and value-added once industrial competitive advantage was lost to other nations in the region, including ship-building to South Korea, computer assembly operations to Singapore, and semiconductor fabrication to Taiwan. Moreover, Japan's long-term sustainable development performance, undoubtedly, had a cultural dimension, built on a substructure of other powerful factors. These included a stable political order; a strong but strategically managed currency; supportive trade unions; a policy emphasis on technology and capital investment, especially human capital; interventionist development policies focused particularly on the promotion of high value-added strategic industries; and a capitalist economic model, elevating profit as the key driver in the search for efficiency and, ultimately, indigenous technological development.

Clearly, even from this brief overview of Asia-Pacific's development push, most of the countries aimed for economic as well political independence. Of course, political and economic self-reliance are not mutually exclusive, in the sense that you cannot have one without the other. Due to similarities in the levels of underdevelopment, it is unsurprising that Asia-Pacific's emerging states had common features in the development planning process. Two of the more important features were import-substitution and an emphasis on diversification away from agriculture via industrialization, hence leading to a premium on technology access. Japan proved to be the development and technology leader in the pack of Asia's emerging developing nations. However, given China's 'late-comer' status, there are similarities between its development paradigm and that of Japan's. Thus, whilst China's development planning since the creation of the People's Republic has been chaotic and stuttering, compared to

Japan's ordered and systematic progression, both countries have focused on state support of high technology strategic or 'back-bone' industries, such as microelectronics, energy, and transportation, including space and aviation. Evaluation of progress in China's aviation manufacturing capacity will be reserved until chapter 5. At this junction, attention will concentrate on China's so called chaotic development planning path.

4.1.2 Origins of China's Industrialisation and Foreign Investment Strategy

To understand the post-1949 period of industrialisation and development, it is necessary to go back several hundred years and identify the critical defining features in China's evolution. The first point to note is that the process of modernisation in China has always included a cultural dimension. Technological development was more than simply a process of physical capital accumulation, it also necessarily included human relationships, both with peers, and, importantly, the deference accorded to those of superior standing in society. Thus, just as European capitalist civilization grew up, inextricably, related to the dominant liberal philosophical tradition, so China's four-thousand-year-old civilization was dominated by the Confucian view (*Rujia Sixiang* 儒家思想) of humanity and society.[5]

However, the last four centuries of Chinese development have been characterised by turmoil, rebellion, civil war, external conquest, as well as the cyclical movement from technological supremacy to economic decay. In contrast to the 16th and 17th centuries when China, as the 'Middle Kingdom' was the innovational centre of manufacturing activity, it stagnated and suffered rapid economic decline in the 19th century.[6] The agricultural sector was huge and entire Chinese economy was tied to grain and food production. Industry had to wait until the start of the 20th century for its 'economic take-off'.

Confucian principles held that correct rules and attitude were the basis of economic and political power and social stability. Men rule because they are 'virtuous'. The virtuous man ~ '*Junzi*'(君子) or 'gentleman'~ generated respect through proper behaviour, lesser mortals responding via obedience and submission. Everyone had a 'proper' place in

Chinese society, a view aptly explained in a statement by Mencius, a disciple of Confucius:

> "Great men have their proper business and little men have their proper business…Some labour with their minds, and some labour with their strength. Those who labour with their minds govern others; those who labour with their strength are governed by others."[7]

If such relationships were properly ordered and people behaved as appropriate to their station in life, then society would be harmonious and prosperous. However, *Li* (harmony 礼) can only exist when appropriate relationships of inequality were developed. This philosophy could be taken one step further, though, because it is not so much *Li* (礼) that is important, but *Hsiao* (孝); that is, harmony is only possible if obedience is given to those who are owed respect because of their position.[8] This hierarchical social philosophy partly explains the iconic Chinese reverence given to the great leader, Mao Zedong in the middle of the 20th century. This cultural model, to a great extent, still reflects the social relationships in China's ongoing 21st century industrial and technological transformation.

4.1.3 Sino-Soviet partnership

The People's Republic of China was formally established on October 1, 1949. From this point, China's political ideology reflected the Marxist writing of Mao Zedong in his work, entitled: New Democracy.[9] China's economy would be built around three principal sectors.

State economy: with government placing under public sector control all the major industries, the key extractive industries, and the utilities.

Agricultural sector: whereby transition from small holdings to big collective farms would be encouraged by the authorities.

Private economy: where 'pockets' of capitalist undertakings, mostly small and medium size enterprises, would be tolerated.

Mao felt that the public sector should lead the Chinese economy towards full socialism. This would be achieved via 'Democratic Centralism', implying the coexistence of these three sectors of the economy under the leadership of the people defined as the proletariat and the Communist Party.[10] However, Mao was clear that in the development of a scientific, socialist culture there was a role, selectively, for useful elements of foreign cultures. Hsu makes the point that the culture of China's *New Democracy* should be national and anti-imperialistic, able to advocate the dignity and independence of the Chinese Nation.[11] Hsu refers to the fact that Mao argued China's hard-won *New Democracy* …"belongs to our nation and bears the characteristics of our nation."[12] Mao's words are significant because they appear to suggest that he felt foreigners could contribute to the economic development of Communist China.

The '*New Democracy*' concept did not last long, however, pressured by its inherent contractions. It was replaced in 1953 with a move obvious bias towards socialism, encapsulated in the launch of a programme called social transformation (*Shehui Zhuanxing* 社会转型).[13] A further, third phase, called Socialist Construction (*Shehui Zhuyi Jianshe* 社会主义建设) was begun in 1956, setting in place the Moscow-Peking economic axis.[14] This was badly needed, as in 1949, economic policy substance and direction were non-existent, and, as a consequence, the economy was close to collapse. Flooding was widespread, and added to this, was the disruption to China's agriculture and infrastructure caused by the long civil war. Thus the obvious outcome was inflation. To address rampant inflation, supply bottlenecks had to be overcome and economic growth expanded. Through the introduction of wage and price controls, the launch of a new currency (*Jen-Miu Piao*) and the imposition of a new taxation system, China's economy were brought back under control within two years. The next step was land redistribution. This was implemented speedily, such that by 1953 some 700mn *mou* (1/6 acre) of land had been redistributed from 'land-lords' to 300mn peasants.[15] This then led the way to agricultural collectivisation, so that by 1954, around 96 percent of all China's peasant households had become members of semi-socialist producers' cooperatives, well on the way to the Soviet collective farm concept.[16]

China did not focus solely on socialist reform and development of the agricultural sector, but simultaneously sought industrial expansion. Development planning was shaped by China's policy aimed, metaphorically, at 'walking on two legs'. This referred to the need to expand agriculture and industry at the same time. China's development approach was Leninist and this viewed industrialization as focusing on capital goods and heavy engineering. It was an approach captured in Lenin's statement… "There is only one real foundation for a socialist society, and it is largely industry."[17] For countries with large economies, such as the Soviet Union, China, and India, a capital goods development strategy is unsurprising. These countries clearly possess the demand and scale to achieve low unit costs of production, potentially enhancing the pace of industrialization. As with the Soviet planning model (See Chapter 2, section 2.3.2),[18] China also employed the use of Five-Year Planning periods. Its First Five-Year plan was expected to be in place by 1953, but because of lack of expertise, especially planning skills and technologies, it was not until February 1955 that the First Plan was implemented. There was thus just 2.5 years of the Plan remaining, but it proved a great success 'over-filling' targeted growth by some way. Industrial growth and capital goods, investment expanded rapidly, not least because of Soviet assistance. The social transformation of the First Five-Year Plan was very much based on Sino-Soviet-Socialist industrial partnership reflected by the fact that out of the Plan's required construction of 694 industrial projects, 156 of them were built with Soviet Aid.[19] The success of the First Plan gave the Chinese government the confidence to be even more ambitious with Second Five-Year Plan, 1958-62. The aim was to increase agricultural and industrial production over the period by a huge 75 percent and economic growth by 50 percent.[20]

The Chinese planners were buoyed with the success of their early development strategy. Building on this success, the National People's Congress announced the 'Great Leap Forward' (*Da Yue Jin* 大跃进) programme. This called for substantial increases in the output of the intermediate and utility industries, such as steel, coal and electricity. There was no limit to Mao's industrial ambitions at the time. He even talked about overtaking Britain industrial capacity by the early 1970s.[21] Looking back, the Great Leap was successful in raising output to higher and higher levels. So in that sense it was a success, yet, it has been subject to criticism because quality was sacrificed for quantity. For instance, in steel production much of the output expansion came from the huge growth in backyard furnaces. The problem was that there was little quality control exercised in these informal sector operations. Accordingly, some 3m of the 11m tons of steel produced in China in 1958 was pronounced unfit for industrial use.[22] This failure of industrial planning mirrored the experience of the Soviet Union in the 1930s. Output targets were met, often superseded, but little attention was given to quality, productivity and process or product innovation.

Notwithstanding these weaknesses, China's economy was growing rapidly. This growth was supported by a powerful alliance with the Soviet Union that went beyond economic fields and included military production and infrastructural projects. These close Sino-Soviet relations were, of course, driven by a common ideological purpose, but also by the pragmatic requirement to build up China's sovereign capability to defend development, particularly against Western imperialism. The 1950 Moscow-Beijing Treaty of Friendship and Alliance became the foundation for China's foreign policy posture for the development of its military-industrial capability, and, significantly, for the early development of its strategic industries, including iron and steel, shipbuilding and aviation. To facilitate this process, the USSR transferred hundreds of thousands of scientists, engineers and military advisers to China, contributing to the latter country's rapid economic, industrial and military transformation. In parallel with China's growing power, Beijing was determined to assume regional leadership in Asia. Whilst peaceful coexistence with neighbours was central to its foreign policy, China was always ready to support regional states in their ideological struggle. For example, China's willingness to send one million 'volunteers' to North Korea to repel what was perceived to be US military aggression.[23]

The first decade, of Sino-Soviet collaboration was thus characterised by a growing strength in relations but also by increasing strains. The stresses included China's efforts to forge an economic development strategy different from that of the Soviet economic system, particularly the divorce of Communist party organisation from industrial management. China also suffered a backlash from the rural–based proletariat against the speed and excesses of agricultural reform and collectivisation. However, the underlying tensions came to a head at the close of the 1950s, through the growing problem of territorial disputes on the northern Sino-Soviet border. These military tensions were not sudden but had festered since the end of War II when Soviet troops entered Manchuria and dismantled and dispatched to the USSR industrial facilities as 'war booty.' Subsequently, Stalin encouraged Outer Mongolia's Independence and maintained control over Manchuria's railways and docks (Port Arthur) until the mid-1950s.

4.1.4 Parting of the ways: China's search for its own development model

Thus, whilst the Stalinist model of economic development had proved useful in a number of ways: in harnessing resources, giving central direction and gaining substantial transfers of technology from the Soviet Union, nationalising all productive means through an optimal blend of *Fengjian* and *Junxian* – a mixture of public and private. Of centralisation and decentralisation,[24] and, finally, industrial growth rather than agricultural development, was understood as the prerequisite for imposing China's military capacity and defending the nation's newly won position of international equality.[25] A Sino-Soviet split was inevitable. It occurred in 1960 leading to the forced departure of thousand of Soviet technicians and advisors. From that time, China began its search for a unique Chinese development model. However, it was not easy, as Maoist thinking was heavily influenced by the May 4th generation of leaders,[26] … "the intolerant sectarianism of Marxism–Leninism, and, in particular, the view that the average citizen of China – seen as the heir of an irretrievably useless and backward tradition - was deeply prone to error unless *properly* led."[27]

China's new development way, then, reflected increased dictatorial powers, inertias inevitably sourced from the head of the Communist Party. It is now recognised that development planning, if that is what it was, from 1958 to 1976 was a disaster, commonly referred to as the 'twenty lost years'.[28] It was an uncertain era, with policy moving from one radical reform process to another. The symptoms of economic demise were becoming more and more evident, such as falling productivity, poor innovational performance, and reduced agricultural output, due to lack of capital investment. The institutional response was to launch, somewhat surprisingly given Mao's contempt of the proletariat's intellectual capacity, an invitation to the masses to provide an agenda for open discussion of national issues, especially economic reform. Termed the 'hundred flowers' (*Bai Hua Ji Fang* 百花齐放) campaign, it was launched under the banner, that 'a hundred flowers bloom, let a hundred schools of thought contend'. [29]

The period of 'openness' did not last long, though, concerned by the flood of criticism and popular uprisings in Eastern Europe, particularly the 1956 Hungarian revolution, Mao brought the hundred flowers campaign to an end in 1957. It was replaced by a strong anti-rightist campaign, leading to repression, a lack of policy diversification, and economic collapse. The period also coincided with the Great Leap Forward a confused and contradictory policy responsible for the terrible famine that reportedly killed upwards of 40mn people.[30] The Great Leap was designed by the basis that agricultural effectiveness was influenced solely by labour utilization. The need to raise capital investment in this sector was a non-issue. Instead, improved productivity and increased output would come from the introduction of People's communes. It was an extreme form of farm collectivization, characterised by people living and eating together in huge 'messes'. Workers would receive part of the output rather than be paid wages. All property was public property, and as a result, the family system disintegrated. Dissenters were seen as ideological radicals and despatched to labour camps. The 'leap' failed to increase farm yields; instead, they declined.[31] Higher and higher output was the priority, irrespective of the manner in which it was obtained. As a consequence, local, prudent, and traditional forms of farming were abandoned. Inappropriate crops were planted and 'fallow' years not undertaken. There was not even control over the number of wells dug, leading to excessive number of wells, and thus causing sharp declines in the water table.[32]

China's agricultural problems eventually began to impact on the manufacturing sector, not least because of food shortages and the disruption to normal education, medical care, and general public welfare. As a consequence, in 1961 the 'Great Leap' was officially ended, and China's search for its own appropriate economic path towards socialism restarted. However, from this point, technology development was at long last given the policy high ground.

Although the role of technology was finally elevated in development planning, the emphasis on its acquisition was derailed by yet another bizarre twist in Maoist revolutionary reform. This had regard to the 1966 Cultural Revolution, reflecting Mao's growing distrust of the Communist Party elite since the traumatic ending of the Great Leap forward policy. Mao had become convinced that the apparent failure of his socialist dream was because of this elite's pursuit of self-vested interests, such as power and short-term economic gains. His policy response was a re-run of the May 4th Great Proletarian Cultural Revolution. Mao intended to refresh the zeal, and change the culture by empowering the youth with revolutionary socialism. The Red Guards emerged and attacked all interpretations of capitalist ideas, including intellectual writings and traditional Chinese thoughts and practises. Contemporary ideology was the only way forward, and its source could only be the thoughts of Mao Zedong. This inevitably created a personality cult, fuelled by Mao's 'little book'.

By the late 1960s it was clear that the Cultural Revolution had brought chaos to China, setting its development-push back by decades. The 'revolution' had also led to enormous loss of life, the destruction of generations of national assets and cultural artefacts, and not least national humiliation in the face of an incredulous international community. Although to begin, these attacks by the Red guards on China's cultural identity, and seats of learning, only impacted on the urban centres, it was inevitable that the rural sector would be affected eventually. Approaching the close of the 1960s, agricultural output began to decline as the chaos of the cities began to affect rural life.

Although the leaders of the Cultural Revolution, Mao, his wife (Jing Qing) and Lin Biao, were for several years in denial at the unfolding social and economic catastrophe, eventually and gradually the excesses of the Revolution were addressed. In the process, 'scapegoats' were sought. At the grass-roots level, literally millions of Red guards were, jailed or sent to prison farms. Mao and his wife tried to place blame on Lin Biao, who attempted to flee the country, but died in the mysterious plane crash. Confusion, chaos and economic stagnation prevailed until 1976, when Zhou Enlai, a senior Chinese Communist Party official died, and later that year Mao passed away. Shortly afterwards, the Cultural Revolution came to an official end, when the Party leadership arrested Jing Qing and other members of the notorious ‘Gang of Four’.

4.1.5 Transition from Communism to Capitalism …

The year, 1976, was a disaster for China, as not only had many of the country’s senior politicians died, but there was also a series of major natural disasters, including an earthquake that destroyed the industrial city of Tang Shan[33] and the flooding of the Yellow River, seven times. However, out of this disorder, a new order emerged, taking China out of this long, dark period.

A number of important events occurred after the passing of Mao that set the stage for China’s phenomenal 1980’s economic transformation. These events included:

- Normalisation of relation’s between China and the rest of the world, particularly the US. This process had begun with US President Nixon’s visit to Beijing in 1972, and therefore the slow but inexorable progress toward the US-China agreement on the establishment of full diplomatic relations, January 1979.
- True normalisation would not have been possible if just political and not economic accords had been agreed. China was keen to cultivate commercial, scientific and technological cooperation with the US. However, progress in these fields, especially trade, and the granting of ‘most-favoured nation’ status, was blocked over the problem of frozen US-China assets since the Korean War.[34] After much negotiation, the unfreezing of China and North Korea’s assets, was agreed in late 1979, thus paving the way for a trade pact that was signed two months late.
- Rehabilitation of Deng Xiaoping, a revered party member with wide political support. Deng’s aim for political dominance was based on his grasp of economics, building his power base by the appointment of young and able economic ‘radicals’.
- Normalisation of relations with the West allowed China to concentrate, finally, on economic development, without the distraction of international military tensions, and regional escapades.[35]

- Additionally, the normalisation of trade between China and other countries, including Japan, enabled China to gain access to modern western technology to drive a new era of development planning, assisting China's new 'long march' towards the Four Modernizations.

These Four Modernisations (*Sige Xiandai Hua* 四个现代化) had been written into the Party Constitution in 1977-1978.[36] The aim of the four modernization was to transform China into a modern state by 2000, with the thrust of policy, prioritising the modernisation of agriculture, then industry, followed by science and technology, and lastly, national defence. At the 1978 first session of the Fifth National People's Congress, Chairman Hua introduced an ambitious Ten-Year Modernisation Plan that would direct huge capital resources at these four key sectors. In the industrial sector alone, investment would be greater than for the entire previous 28 years, estimated at US$400bn, with the target rate of annual economic growth at 10 per cent.[37] Hua planned for the completion of 120 major projects, including 10 iron and steel complexes, six oil and gas fields, 30 power stations, eight coal mines, nine non-ferrous metal complexes, seven major trunk railways, and five key harbours.[38] Similarly impressive investment funding was allocated to the other three sectors within a broad modernisation programme.

Whilst the implementation of the Four Modernisations was far from smooth, with the authorities struggling to contain inflation, foreign exchange shortages, and the cultural difficulties of moving from economic disorder to ordered development, the policy nevertheless represented a platform for economic and technological advancement. However, a totally new paradigm was required. The Maoists had always emphasised the importance of self-reliance…

> "Politically, 'wholesale Westernisation' meant loss of sovereignty and national humiliation, a total sell-out of China's independence and self-determination … Ideologically, 'wholesale Westernisation' was meant to praise what was foreign and belittle what was Chinese … Economically, 'wholesale Westernisation' was aimed to spreading a blind faith in the Western capitalist material civilization as to turn the Chinese economy into a complete appendage of imperialism."[39]

The acceptance of economic self-reliance would not change, but Deng Xiaoping recognised that to achieve this goal, access to foreign technology would be required. Deng and his associates were at the helm of a new ‘technological’ Great Leap. The Chinese leader assumed that science, technology and the dynamics of technological change were basically politically neutral and classless, and that they could be transplanted without any injury to Chinese social and cultural institutions.[40] Thus, the political and economic stage was set for Deng’s ‘Open-Door’ policy and the rapid economic transformation of China via its unique ‘market-socialist’ (*Shichang Shehui Zhuyi* 市场社会主义) planning model.

The 1978 reforms began in the countryside. After a decade of chaotic Maoist agricultural collectivisation policies that sought to raise grain production and keep prices low, reform was deemed necessary to allow farmers …“to catch their breath.”[41] Output targets were held and prices raised in a gradual way, with above target deliveries rewarded though higher prices. Liberalisation policies were gradually introduced, but the most dramatic development came from the Chinese farming community itself, de-collectivisation of land via contracting-out of individual lots of land to farm households. This was a major reason for the rapid increase in China’s grain output reaching 407m metric tons in 1984, more than one third higher than in 1978.[42]

There were opportunity-costs associated with this short-run adjustment process of injecting greater efficiency into China’s agricultural community, such as the emphasis on investment and the scaling-bank of the country’s ambitious ‘leap outward’ technology import (*Zouchu Guomen* 走出国门) programme. However, the liberalisation process had begun, and was proving so successful that the process of stabilisation was extended to the broader commercial economy. It was a process of de-centralisation that was to last for approximately 15 years (1978-93). This first phase of China’s reform experience facilitated the introduction of liberalisation, concentrating on agriculture and basic industrial segments, promoting rudimentary competitive processes, decentralised control and resource management, and reform with minimum associated risk. As can be seen from Table 4.1, these attributes contrasted sharply with the reforms that characterised China's second development phase from 1993 onwards.

Table 4.1: Contrasting Systems of Economic Reform

1980's reform	1990's reform
Zhao Ziyang: Cautious, consensual decision-making	*Zhu Rongji*: Rapid, personalized decision-making
Introduce markets where feasible; focus on agriculture and industry	Strengthen institutions of market economy; focus on finance and regulation
Dual-track strategy	Market unification, unite dual tracks
Particularistic contracts with powerful incentives	Uniform rules: 'level playing field'
Competition created by entry; no privatization	State-sector downsizing; beginnings of privatization
Decentralize authority and resources	Recentralize resources, macroeconomic control
Inflationary economy with shortages	Price stability, goods in surplus
'reform without losers'	'Reform with losers'

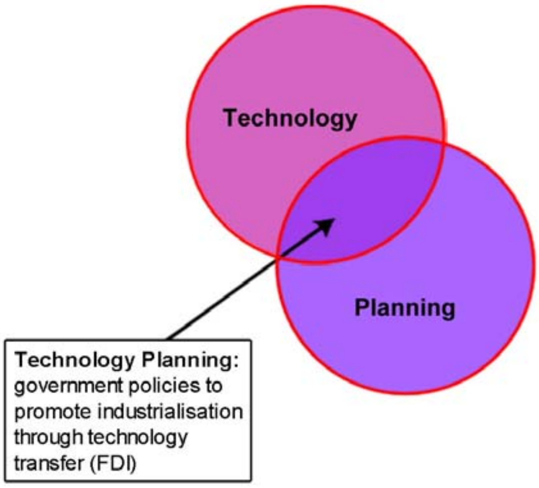
Source: Naughton, B, *The Chinese Economy-Transitions and Growth*, MIT Press (2007), p91.

4.2 TECHNOLOGY PLANNING: *Kaifeng Zhengce* and the Role of FDI in China's Industrial Transformation

For the past three decades, China has been seeking to expand and deepen economic development, particularly industrialisation, through local technology planning. It represents the second of the three macro-development and planning processes defined in Figure 2.10. The correspondence between the technology dimension in Chinese development and planning is illustrated in Figure 4.2, below. Technology planning emphasises the importance that China's policymakers attached to inward technology transfer.

Moving beyond the 'Great Leap Forward' and the 'Cultural Revolution' policies of the 1970s, there was an emerging paradox surrounding China's technological transformation. This had regard to major industrial and technological programmes occurring at the same time as the re-development of agricultural small-holdings and

Figure 4.2: Technology Planning



Source: Author, abstracted from Figure 2.10.

small manufacturing enterprise. It is remarkable that the 'bottom-heavy' household-based economy survived the 1949-78 economic turbulence associated with China's 'big push' industrialisation strategy, surviving the excesses of the Maoist economic revolution. Nevertheless, it did, and the 1978 reforms supported the development of both small and large scale sectors; the informal and formal players benefiting in equal measure from rapid industrialisation.

It is on the development of the large industrial sectors, however, that this study focuses. Whilst agriculture and light industry played, and continues to play, an important role in China's development, Beijing's technology planning regime concentrated on the promotion of strategic 'strategic' industries. This was partially because of their powerful contribution to PLA military capability, and, additionally, because they represented both the growth poles of a modern economy and the basis for self-sustaining industrial and technological growth. This section, then, examines the early reforms introduced in 1978 at the time of Deng XiaoPing's 'Open Door' policy. It will emphasise the policy on FDI, welcoming foreign investment to facilitate access to foreign technology. The section goes on to explore the costs and benefits of FDI in the Chinese context, prior to examining a principal form of technology transfer, licensed production, which is of particular relevance to the development of China's fledgling aviation industry. Licensed production is characterised by technology 'offset', an under-researched but nonetheless critical vehicle for technology transfer to developing countries. Once the technology has been transferred, the need is then to outline the Chinese way of corporate development and the importance attached to long-term planning, networking and partnership.

4.2.1 Post-1978 Market Reforms for Fostering Technology Development

Remarkably, China's market economy model that emerged from decades of radical and disruptive Maoist Socialist economics occurred without any 'big bang'. Liberal polices were introduced to encourage entrepreneurship, risk taking and the search for profit. The approach was uneven, unbalanced, and in some respects disorganised. It worked, however, because the Chinese planning authorities recognised from the start that China was a developing country where economic development was, and remains, the priority, rather than solely political transformation. However, there was no development blue-print; the reformers simply seeking to address allocation weaknesses and bottlenecks as they existed or appeared. Under this approach, no distinction was made between the resource inadequacies of under-development and the inefficiencies of the command economy. Chinese reformers simply applied the market formula to revealed weaknesses in the system as a means of getting the economy working. Barriers were reduced or removed to create opportunities for local investors, and foreign firms were encouraged to transfer capital and operate in special economic zones. What emerged over time, was a unique mixture of socialist planning apparatus and 'unplanned' market principles and policies.

4.2.2 'Open-Door' (*Kai Fang*) Industrial and Technology Reforms

The catalyst for China's market transition was Deng Xiaoping's 1978 'open-door' policy. This heralded an economic reform programme designed to remove the dead economic hand of Marxist ideology, replacing it instead with an enlightened 'dual-track' system (*Shuan Gui Zhi* 双轨制).[43] This describes the industrial and technology planning approach adopted by China as one which considers central planning and market reform as a combined entity. From 1978, the dual-track system allowed dual prices; that is, state controlled prices for essential goods. The state prices were typically higher, unregulated, market prices. Additionally, the dual-track model permitted the central planning authorities to prioritize investment into predetermined key sectors, such as energy, infrastructure and transportation. It is important to note that these two forms of resource allocation system were not mutually exclusive; rather they operated in an interdependent way. State enterprises traded with non-state companies, and increasingly, foreign business became an integral part of this socialist (planned) and market (liberalised) Chinese economic model.

Deng Xiaoping's reform process centred on re-establishing the importance of learning within the culture of China. Science and technology was the third of the four modernisations and was considered an essential pre-requisite for successful modernisation. At the national science conference (March 1978) a draft outline National Plan for the development of Science and Technology was presented by Vice-premier Fang Yi. The Plan emphasised the need to close the technology gap with the advanced countries through directing investment towards 27 priority fields.[44] Underpinning this planning was the recognition that education had to be the driving force for change.

For over a decade, China's traditional deference to the significance of education was undermined by Mao's chaotic Cultural Revolution and the later, somewhat contradictory views, espoused by the Gang of Four. In this regard, note the Gang of four's claim:

> … "the more a person knew, the more reactionary he would become … [The Gang of Four] … preferred labourers without culture and praised an ignorant reactionary clown who handed in a blank examination paper as the model of a 'red expert'. On the other hand, they vilified as 'white and expert' those good comrades who studied diligently and contributed to the motherland's science and technology. For a time, this reversal of right and wrong and confounding of the people with the enemy caused deep confusion in many minds."[45]

China's leaders knew that for the reform process to promote development there would need to be a push on industrialisation. Technology would be the critical input in this effort, with technology planning focused on technology access. In this regard, Cliff argues that three factors influence the success of technology planning: technology effort (R&D and the associated policy strategy); human capital investment (reflecting the sustainability of technological capability); and institutions and incentives (determination of the size and focus of the knowledge effort).[46]

4.2.3 China's Research and Development Push

Developing countries, such as China, are defined by their lack of R&D expenditure. In the initial development period, agriculture would be dominant, manufacturing would be limited, and technological capability scarce. Typically, it would be decades before R&D expenditure occurs, but even then, R&D/GDP ratios would average around just 1% of GDP.[47] For instance, it was not until the 1980s that Taiwan and South Korea managed to break through the 1% threshold. For the advanced countries, such as Japan, Finland and Sweden, R&D ratios are above 3% of GDP. Table 4.2 details the R&D ratios for a selected group of countries.[48] It is clear that China, along with other so called BRIC (Brazil, Russia, India and China) countries, have ratios at or below the 1% level. Similarly, the number of Chinese researchers per 1,000

Table 4.2: Comparative R&D metrics for selected countries

	R&D outlays (percent of GNP)	Researchers (per thousand total employment)
China (2003)	1.1	1.2
Mexico (1999)	0.4	-
Brazil (2000)	1.1	-
India (2001)	0.9	-
Taiwan (2003)	2.5	7.1
Korea (2003)	2.6	6.8
All OECD (2000)	2.2	6.6
France (2002)	2.2	7.5
United States (1999)	2.6	9.3
Japan (2003)	3.2	10.4
Sweden (2001)	4.3	10.6

Source: Naughton, B, *The Chinese Economy-Transitions and Growth*, MIT Press (2007), p392.

employed is low compared to other countries. From Table 4.2, China's ratio is the lowest by a large margin of the countries shown. However, these are relative measures, and if absolute values are examined, then significantly, China has the world's fourth largest R&D spend, after the US, Japan and the European Union;[49] and possesses the world's highest number of researchers per 1,000 of employment.

4.2.4 Human Capital Investment

Rising investment into human capital is needed to sustain local technology effort. Skill enhancement represents one of the key attributes of technological development and this has been recognised by the Chinese planning authorities. Growth in the number of R&D workers has been remarkable, such that by 2004, China had 1.16 million people employed in this sector, and of these, 920,000 were scientists and engineers.[50] Science and engineering graduates currently make up around 45% of all graduates. It is not just that China is producing around one million science and technology graduates annually; it is also that the pace of increase is accelerating.[51] Clearly, if this continues, then China will have the greatest science and technology resource (and research) base in the world.

Caution is required, however, in the interpretation of the above figures. This is because the volume of R&D effort and the volume of researchers say little about the quality of these inputs. On the other hand, China has succeeded in pushing the boundaries in selected high technology areas, such as intercontinental ballistic missile development and space travel; these being fields where huge resources have been targeted for often military reasons. Yet, R&D for the average enterprise in China is more a pseudonym for training and basic maintenance activity.

Aside from China's efforts to foster local science and technology training and education, there is a sizeable and growing involvement of foreign research/training opportunities. This has two levels. Firstly, there are the huge numbers of Chinese professionals trained and educated overseas. Official Chinese data indicate that more than 700,000 Chinese studied abroad from 1978-2003 and that 172,000 returned after graduation.[52] Although only one in four Chinese professionals returned to China after graduation, it is likely that the numbers returning will increase as the momentum of technological change in the country expands opportunities for highly skilled personnel. Moreover, even if China's overseas graduates do not return, they will still play a critical role in the development of international research and innovation networks that incorporate Chinese enterprises.[53]

4.2.5 Institutional Technology Policy

China's institutional focus on the development of science and technology goes all the way back to the 1950s. From a very early stage in the country's development push, powerful research establishments were created, including the Chinese Academy of Sciences. As previously mentioned, however, much of the research effort was diverted towards strategic objectives, including the bias towards heavy engineering. The focused research effort and emphasis on capital goods production emulated Soviet science and technology planning in the 1920/30s. Both the Chinese and Soviet models operated in a consistent way within the command economy system, with Moscow's important role in technology transfer and collaboration with Chinese enterprises in the 1950s extending to influencing the structure of China's national R&D system. It was thus a centralised and unwieldy system of government-owned R&D centres unrelated to market pressures or incentives. When the separation occurred between the Soviet Union and China in the early 1960s China was left without access to technology or MRO support from critical technology suppliers. Over the next 15 years, therefore, China's R&D framework deteriorated and capability stagnated. Activities fell back to 'reverse' engineering of aging foreign designs and the maintenance of existing systems. As a consequence, the technology gap between China and advanced countries widened, not reduced as originally planned.

'Open-door' policy liberalisation measures impacted on China's R&D system just as they did on other sectors of the economy. Firstly, there was a change in the structure of R&D funding. Naughton notes that from a position in the 1980s, where government research accounted for two-thirds of total R&D expenditure, this had changed by 2000, such that 60% of R&D activities were carried out at the enterprise level; this being a similar share as their counterparts in market economies.[54]

Secondly, in addition to the changed structure of funding, there is evidence that enterprise-level R&D expenditure was having an impact on organisational performance, including technology absorption capability. Hu et al, for instance, found that firm-level R&D and foreign technology transfer are positively associated.[55] Additionally, Fisher-Vanden et al linked firm R&D to the development of product technologies able to exploit China's abundant labour resources, whilst at the same time minimising the use of scarce resource.[56] Also, a number of big commercial organisations were beginning to invest substantial amounts of money into R&D. For instance, in the information technology field, Huawei and ZTE are undertaking R&D spending of 14.7% and 7.6% against gross revenues, respectively.[57]

Thirdly, government policy, post-1978, has been acting to encourage R&D and high technology activity in China. This has been done through numerous policies, mostly implemented since the late 1990s, and aimed at incentivising high technology activities. This has been done through a broad-based policy implementation approach, in which an important aspect has included the widening definition of 'national industry' to incorporate firms with a large measure of foreign investment. Associated with this policy change was the greater flexibility of the Chinese authorities in granting foreign investments, thus accelerating the pace of inward technology transfer. Aside from inducements to attract foreign capital, there has been a substantial programme of government support measures designed to promote high technology development. These measures included: tax exemption on R&D investments; subsidized credit for SMEs engaging in high technology exports; government procurement prioritised towards local high technology firms; introduction of local technical standards, representing an import barrier to foreign firms exporting to China; and the implementation of provisions enabling Chinese high technology enterprises to access capital by listing on the local stock exchanges.

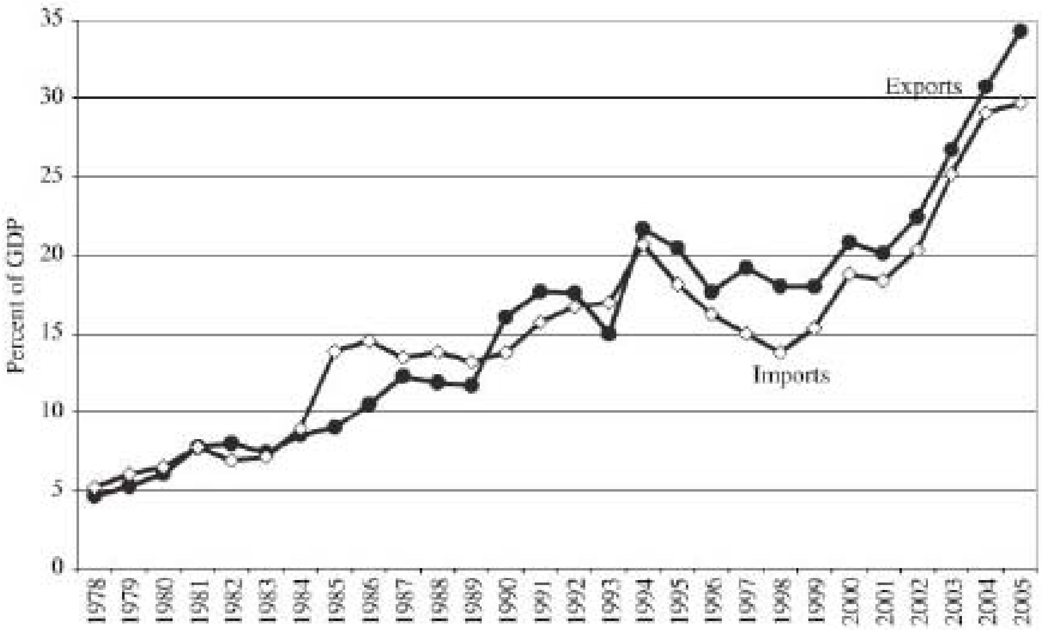
Government, policies such as those above, have been aimed at energising business endeavour in China's high technology sectors, supported by government expansion of R&D activities. Much progress has been achieved, evidenced by China's incursion into a broad range of high technology areas, such as microelectronics, telecommunications and aviation. Challenges remain, however, not least the need to raise local value added. It is right that China develops policies to move local firms up the value chain, as characteristic of modern business is to become embedded in international value chains, both as a supplier and as a customer. Lenovo, for instance, has created a strong international brand by focusing on the promotion of local technological development, but, at the same time, it has outsourced much technology work through international subcontracting networks to Taiwan.[58] Of course, working the other way, foreign companies, like Motorola, will subcontract work to Chinese companies. However, the efficient operation of these international technology networks is based on trust, particularly in the protection of IPR, and also a commitment on the part of government to liberalise international trade.

4.2.6 International Trade: 'Reform and Open' (*Gai Ge Kai Fang*)

There was no doubt that liberalisation by itself, would have had a reduced impact on China's technological development without policies aimed at opening up the economy to the economic opportunities offered through international trade. The planning authorities viewed the opening up of one of the world most 'closed' economies and progressive domestic liberalisation as a complementary process. However, dramatic de-regulation was required to move China away from a command economy model towards a hybrid transitional approach leaving intact, national (typically inefficient) government-owned enterprise, but also introducing limited exposure to international trade. Yet, this is not to state that since China was formed, it has had no trade; international transactions did take place, though in the 1950s, trade was mostly with other Communist states. Indeed, around 48% of China's trade in this period was with Soviet Union alone.[59] Later, however, following the breakdown in Sino-Soviet relations, China's trade stagnated, it picked up in the late 1970s with oil exports and technology imports from the US and Japan, but inefficiencies of the command economy meant that China's trade position remained fragile.

Figure 4.3 shows clearly China's upward trajectory in exports and imports (against GDP) from 1978. However, to secure this 'explosive' growth in trade, China first had to overcome its rigid command economy trading regime, characterised by the following conditions: government-controlled foreign trade monopolies that dominated the flow of imports and exports; a Chinese currency (RMB) that was centrally determined and nonconvertible; and foreign exchange that was only released through special authorisation. Thus, in 1970-71, China's total goods trade (exports plus imports) represented only 5% of GDP.[60] Moreover, the Communist system was not designed to support an efficient trading system. It was more to do with achieving growth and output targets. Cost was not a factor under this approach, nor was allocative efficiency. China's post-1978 'openness' policies had transformed its trading performance. The command economy's strategy was, as discussed in Chapter 2, focused on capital-goods industrialisation through an import-substitution growth strategy. In this respect, trade was simply to facilitate import-substitution. This was done in two ways: firstly, importing goods that could not be produced by local Chinese firms, thus overcoming domestic bottlenecks, and, secondly, by importing machinery and other process equipment to promote import-substituting industrialisation. Exports were therefore down-played, of little importance, except in providing the scarce foreign exchange to support imports. This disconnected trading regime had the effect of reducing economic growth in the post-1978 period, because rising technology imports quickly exhausted China's limited foreign exchange reserves.

Figure 4.3: China Export and Import (Share of GDP) Performance, 1978-2005



Source: Naughton, B, *The Chinese Economy-Transitions and Growth*, MIT Press (2007), p378.

In response to the above barriers to China's efforts to promote trade, urgent policies were introduced to reform the country's foreign trade regime. Almost immediately, in the latter years of the 1970s, policymakers launched two Special Economic Zones (SEZ): one in Guandong - close to Hong Kong, and the other in Fujian – close to Taiwan. The SEZs provided beneficial investment opportunities, tax concessions, faster customs procedures, and duty-free importation of components and related supplies. The idea was that the SEZs would facilitate trade by exploiting the demand and trading networks existing in nearby Chinese-speaking capitalist markets. Hong Kong, for instance, was already a major trading power in 1978, exporting as much as mainland China at that time.[61] Whilst the SEZs were created to attract investment and create capacity, their ultimate purpose was to act as Export-Processing Zones (EPZ). Under this capitalist system, Guangdong, especially, grew rapidly in the 1980s/1990s, but without compromising the broader Communist economic system built around the monolithic state-owned enterprises.

After these early modest initiatives, China's policymakers began to liberalise the wider trading framework. Significant reforms were gradually introduced from about the mid-1980s onwards. To begin, the exchange rate 'problem' had to be addressed. Under a command economy, China had maintained a strong (over-valued) currency, ensuring that import prices were low to reduce to cost of necessary imports. The move to open-up trade required that the exchange rate be weakened, placing greater emphasis on exports through a depreciated currency. China's manipulation of the RMB was a necessary feature of transforming its trading system from one focused on import-substitution to export promotion. Alongside currency depreciation, the numbers of Chinese businesses allowed to participate in international trade grew rapidly. These included both SOEs and profit-driven private enterprise. Incentivization was also fostered by the Chinese authorities. Exports grew not only because foreign exchange could be retained by exporters above government determined targets, but also because of the broader ability of firms to earn profit; indeed, this reflecting profit maximisation through greater efficiency. Costs were suddenly important, and, equally, world prices slowly began to provide the economic signals for domestic production, as opposed to the command economy model where prices were planned. As with all other industrialising nations, China sought to protect the domestic economy from external competitive forces. Not least, the planners were keen to promote designated key economic sectors, and so barriers were erected. Such barriers were designed to protect and promote local industry through direct tariffs, non-tariff barriers and import quotas.

The early stages of the trade liberalisation were aimed at consolidating the process of import-substitution alongside modest export expansion. However, China's planners were aware of the highly successful exporting models of Asia's newly industrialising economies, such as Taiwan and South Korea, and they thus sought to copy these export-driven models. Accordingly, export VAT rebates were introduced in the late 1980s and preferential interest rates on loans to exporters were introduced shortly thereafter. These measures helped to promote Chinese export growth, but the really important reform was the development after 1986 of China's 'coastal development strategy'. Nearly all businesses in the coastal provinces were allowed to trade and engage in processing and assembly contracts. For the first time, overseas investors were allowed to enter into the export-processing system, 'owning' the imported components and raw materials that were imported duty-free. Fairly rapidly, administrative flexibility was introduced, enabling foreign enterprises to avoid the bureaucracy and administrative complexity of China's import controls and regulatory framework. Most importantly, foreign businesses benefited from tax concessions and were not required to trade via the state Foreign Trade monopolies to import their manufacturing inputs.

From these early and cautious liberal reforms, China's trading system began to open-up, and move towards a fully open economy. China had ambitions of joining the world Trade Organisation (WTO), making its initial application to the General Agreement on Tariffs and Trade (the organisation that preceded the WTO) in 1986. However, the bid proved unsuccessful, and it was not until December 2001 that China was finally accepted as a full number of the WTO club. The delay was partially political, linked to the 1989 Tiananmen Square incident, and partially economic, given China's threatening expansion in economic power over the intervening years. A new trading era now had begun, however, with China committed to fully opening up its economy, reducing trade barriers to foreign goods, capital and investment, and committing itself to the protection of foreign companies' intellectual property rights. China's eventual WTO 2001 membership was yet another step towards technological self-reliance. Inward technology transfer via the vehicle of foreign direct investment was expected to accelerate the process of Foreign Direct Investment that had begun with Deng Xiaoping's 1978 open-door policy.

Foreign investment began to move into China in a big way from the early 1990s. FDI flows have been above US$40bn since 1996, and higher than US$60bn since 2004; indeed, in 2007 inflows had risen to above US$67.3bn.[62] Such flows are the biggest of any developing country, though far short of advanced country FDI. Technology planners have been required to 'manage' these capital inflows. FDI has been directed towards manufacturing, providing capital, technology and skills. Some of the FDI has been centred on high tech. operations, such as semiconductors, telecommunications, optic fibres, information technology, and aviation. In this respect, FDI has been viewed by China's policymakers as far more important than portfolio capital, venture capital or commercial bank finance. Partially, this is because of the broader economic benefits, such as technology transfer, associated with FDI. Also, whilst much of the FDI has moved within the 'bamboo curtain', ie, FDI flows moving into China from the Chinese business diaspora in Asia-pacific, there have also been significant strategic FDI transfers from the rich countries.

China's contemporary period of technological development only really took root following the 1978 policy reforms. These reforms impacted on FDI, and, as discussed in the last section, provided opportunities to foreign investment enterprise in the Guangdong and Fujian provinces that 'kick-started' the FDI process in China. However, these capital inflows were marginal throughout the 1980s, with the Chinese authorities liberalising regulations in a cautious way; the Chinese fearful of foreign economic domination. Then, in 1992, FDI jumped, beginning an exponential rise that has only recently begun to moderate in 2008, probably as a consequence of the present global recession.

There is not one answer to explain why FDI surged after 1992, but probably the most likely reason is that sufficient time had passed since the 1989 Tiananmen incident, and the uncertainty that had been created in the foreign business community had started to fade. Moreover, confidence had been restored by Deng Xiaoping's important 1992 'Southern Tour' aimed at re-establishing the reform agenda and reassuring foreign business that China was a safe and efficient country to invest. The liberalisation culture was now finally embedded in the dualistic market system. Infrastructure had been built up, and further reform was promised. In particular, the scope of FDI opportunities was planned to increase. Many new sectors would be opened up to FDI, and beyond that, foreign businesses would be able to sell their output in the domestic market. For the first time, then, there would be a more balanced focus between export-oriented production and domestic market expansion.

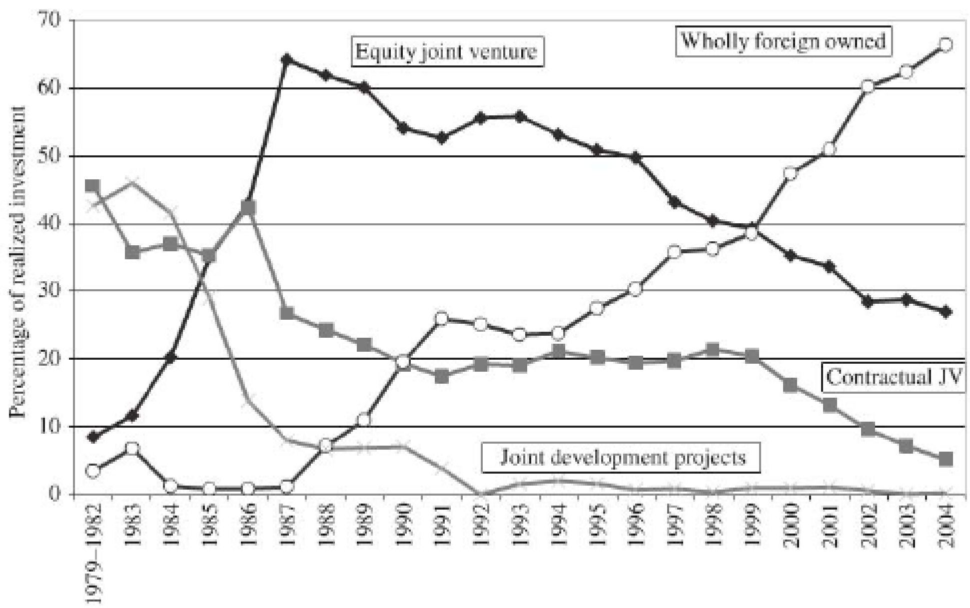
At the heart of policy efforts to promote FDI were the SEZs. They acted as a bridge from the traditional command economy that still dominated China, and the liberalisation process then beginning to characterise geographical pockets of capitalist production around China's coastal areas. The SEZs provided an open economic environment conducive to foreign firms doing business in China. China's SEZs were not fundamentally different from the export processing zones (EPZ) that had been created across Asia since the mid-1960s. The common ground between these two types of zones was that they emphasised an export-bias for firms within the zone but without altering the protectionist import-substitution regime in place for the rest of industry.

China's SEZs grew in importance and number. 'Open-Cities', including Shanghai, were begun, offering most of the investment benefits attached to SEZs. Additionally, Economic and Technological Development Zone (ETDZs) were started, located especially along the coastal provinces, allowing flexibility to attract foreign businesses. Even though Chinese law at that time only allowed foreign ownership within the SEZs, around 18 new ETDZs were created in 1992-93.[63] By 2007, there were over 5 SEZs and 49 ETDZs in China.[64] Furthermore, China's encouragement of FDI was now extending into the interior, towards the relatively underdeveloped Western regions.

Today, every Chinese province possesses a SEZ of one type or another, providing a more balanced planning framework across China.

The SEZs have without doubt facilitated foreign investment in China. The advantages in place are attractive, including low taxes, the facility to convert currency, and the unrestricted opportunity to repatriate profit. In addition, the SEZs operate in a decentralised way, with flexibility to bypass time consuming state regulations, speeding up business decision-making. IPR protection remains a challenge, but WTO membership ensures that the authorities are committed to strengthening the measures to protect IPR. Hand-in-hand with such liberalisation has been the changing structure of

Figure 4.4: Modes of FDI in China



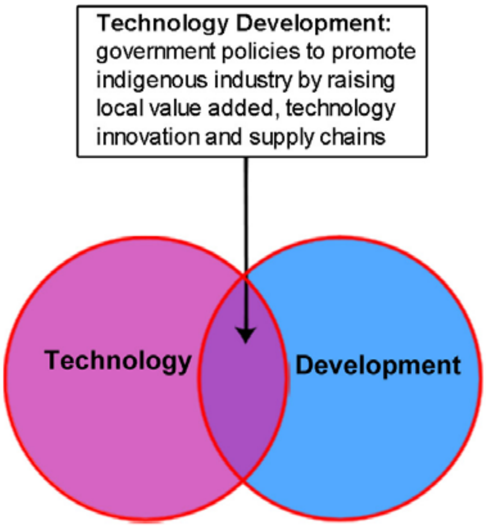
Source: Naughton, B, *The Chinese Economy-Transitions and Growth*, MIT Press (2007), p412.

FDI. Immediately after 1978, most of the limited foreign investments entering China were contractual joint-venture operations. Profit would be shared on a mutually acceptable basis. Joint development projects were also prominent, but both these forms of foreign investment declined over time. Replacing them were equity joint ventures. These created a legal identity, suggesting a long term relationship or partnership in directing the venture. China felt this type of foreign investment would encourage greater access to foreign technology; however, the reality was that foreign business was more interested in seeking short-term profit, so inevitably tensions between the partners would surface. With China's progressive move towards more open and market-based structures, policies have evolved to promote FDI through wholly-owned subsidiaries of foreign corporations, and, as Figure 4.4 shows, this has now become the dominant form of FDI Model in China.

4.3 TECHNOLOGY DEVELOPMENT: China's Push for Indigenisation

The previous section examined the strategic frameworks for technology access to support Chinese industrialisation, where the emphasis, certainly since the 1980s, has been on FDI. However, attempts to access foreign technology go much further back to the late 1950s and 1960s, when China encouraged strong collaborative links with Soviet industry, particularly in the heavy engineering sector. More recently alongside FDI, China has put work in its factories, technology offsets; this applying especially to the defence and aviation sectors. As part of this process of inward technology transfer, China, as with other Asian development states, such as South Korea and Japan, has introduced parallel policies to develop the technological base of its economy. Of course, it is helpful to encourage short-term economic multiplier benefits of employment and income generation, but if the long-term goal is indigenous industralisation, but further policies are required.[65] Consequently, China has targeted local and foreign resources towards higher technology output on the basis that such high value activities are consonant with progression towards local technological development. This section thus completes the cycle from development planning (broad-based economic development strategies), to technology planning (Five-Year Plans to diversify the economy away from agriculture and labour-intensive production to manufacture, facilitated by FDI), to technology development (policy emphasis on the development of 'local' high technology industries that are high value, knowledge-intensive and innovative), see Figure 4.5.

Figure 4.5: Technology Development



Source: author, abstracted from Figure 2.10.

4.3.1 China's Technology Development Policy

Beijing's ambition to foster technological self-reliance has long been linked to the need to promote science and technology. This point is subtly emphasised in the statement by Liu Huaqing:

> … "without advanced science and technology and people armed with advanced science and technology, modernisation is empty talk."[66]

This has been a consistent theme since 1949, China's year of independence. Indeed, it was programmed into the country's First Five-Year Plan (1953-57). The aim was to develop infrastructure for China's S&T system. Rapid progress was achieved, such that by 1955, a total of 840 scientific and technology research institutes had been set-up compared to only 40 scientific research institutes in 1949.[67] In January 1956, the Chinese government issued its First Plan on the Development of S&T – the 'Long Term Plan of Science and Technology Development in China from 1956 to 1967' (often abbreviated to simply the '12-year Programme', *Shiernian Kexue Jishu Fazhan Yuanjing Guihua* 1956-1967 年十二年科学技术发展远景规划). Some 616 key technology projects in the 12-year programme covered major technological areas that were critical to China's industrialisation ambitions, including computer and automatic technology.[68] In March 1962, China's National Commission of Science and Technology issued the

‘Plan of Scientific and Technological Development from 1963 to 1972’ (‘10-year programme’, *Shinian Kexue Jishu Guihua Gangyao* 1963—1972 年科学技术规划纲要). This Plan ran in parallel with China’s military priorities and contributed to the development of nuclear weapons, missiles and satellites. The later 8-year programme (1978-1985) continued to focus on the creation of a comprehensive S&T capability. During this plan, 108 research projects were undertaken in the fields of agriculture, energy, materials, computers, lasers, space, high energy physics and genetic engineering.[69] Into the 1980s, China’s S&T policy began to focus on reform and dynamism. The big S&T policy initiative was the ‘Decision on the Reform of Science and Technology Management’ (1985 Decision), and the 1995 ‘Decision on Accelerating Scientific and Technological Progress’ (1995 Decision). These two important policies played an important role influencing China’s technological development over the last two decades. The 1985 decision began a series of reforms in the S&T system with regard to its structure, funding and human resource management. One important change was that research institutes previously reliant on government funding now had to bid for private sector funds. Building on these reforms, the 1995 Decision focused on the need to strengthen the relationship between S&T and economic growth. Thus, the 1995 Decision emphasised 11 critical policy areas, including: implementation of the idea that science & technology are primary productive forces in all fields; improvement in the quality and efficiency of industrial growth through advances in S&T; development of high technology industries; training of a contingent of highly qualified S&T workers to enhance the nation’s technological level; and further opening-up China to the outside world to extensively launch international scientific and technological cooperation and exchanges.[70] The thrust of the 1995 policy was to reinforce a long list of earlier growth-biased S&T initiatives shown in Table 4.3:

The development of China’s early S&T infrastructure was remarkable in the breadth of its scope. However, it was a system modelled on the Soviet approach, which was highly institutional and bureaucratic. The biggest failings have regard to the separation of institutional research (including government research institutes and universities) away from the production units.

This lack of cohesion meant that although indigenous S&T leading to innovation had been at the heart of China's S&T policy since 1949, little local technological development had occurred up to the new Millennium. To overcome this problem, Beijing began to emphasise the lack of contradiction between indigenous development of S&T and international cooperation along with the importation of technology. It was believed that international cooperation with advanced countries would be a short-cut to narrowing the technology gap between China and the advanced nations. This S&T approach also aligned with the more general economic model emphasising China's open-door philosophy.

To further improve indigenous S&T, the Chinese government stated in the early 1990s that the goal for total R&D spending (public and private) was to reach 1.5 per cent of China's GDP by the year 2000.[71] To use public funding effectively, the Chinese government must give priority to basic research and high technology research and let normal commercial technologies be driven by market forces.

Table 4.3: China's Growth-Biased S&T Policies

	Policy	Year
-	National Key Technologies R&D programme	1982
-	High-tech R&D Programme (863 Plan)	1983
-	Spark Programme (Promoting Rural Economy)	1986
-	Torch Programme (Developing New High-Tech industries	1988
-	National New Product Programme (high-tech)	1988
-	National Medium and Long-Term S&T Development Programme	1990
-	Climbing Programme (Basic Research)	1991
-	National Programme for Key Basic Research Project (973 programme)	1997

Source: Adapted from Wang Pei, The Challenge: Promoting China's Defence Science and Technology Capability, MOA, No 18, Thesis, (2004), pp40-1.

In the '95 decision', Jiang Zeming advocated … "stabilize on one side, but let the other side be free" ("*Wenzhu yitou, Fangkai Yipian*" 稳住一头，放开一片).[72] The one side which needs to be stabilized refers to basic research and applied basic research. The other side to be free refers to applied research. This notion means the government should emphasize basic research and let the market, support applied research. This philosophy has three-fold underpinnings: first, basic research is very important because it lays the foundation for applied research and refers to the long-tem, sustained development of S&T; second, most enterprises are reluctant to invest in basic research, due to the high risks inherent in basic research, thus to guarantee the sustained development of S&T, the government should support and fund basic research; third, "let the other side be free" can facilitate a close combination of applied research and economic growth. In implementing the "stabilize on one side, but let the other side be free" policy, China continued to reform its S&T systems in the 2000s, with a view to accelerating technological development.

In 1986, China introduced the 863 Plan which was aimed at raising the degree of 'dual-use' civil-military integration in the Chinese economy. This was followed by further measures in the following decade, such as Plan 973. In the present century, the pace of China's technological development has increased rapidly. This is partly to do with increasing corporate R&D, partly to do with governmental sponsorship of R&D and partly because of the mix of government measures to raise local absorptive and innovative capability. The Chinese government's industrial policy has very much targeted priority sectors and traditionally, that has meant public-owned manufacturing enterprises. In reality, during the past 10 years, China's industrial policy has been integrated into technology policy.[73] The country's push for technology development has been supported by a spectrum of incentives designed to develop a sovereign and sustainable knowledge-intensive economy. However, sovereignty may not necessarily be translated as business-under-Chinese-control. China's 'national industry' has been redefined to include foreign investments and also small and joint-venture start-ups.

Promotion of high technology industry is arguably the central economic development policy of the Chinese government during the present decade.[74] This is reflected by the way in which long-term development of human capital is promoted and via high tech-exports, particularly those in which China owns the IPR. Alongside foreign investment the Chinese authorities have promoted local technology development through the use of tax breaks on R&D expenditure, subsidized credit, and domestic high-tech firms enjoying government procurement preference, the introduction of corporate governance provisions to sponsor venture capitalists, and the creation of competitive advantage by manipulation of technological standards. The focus on technological self-reliance has been a constant theme in the history of Chinese development. It has come to the fore again, since the late 1970s, when China's open-door policy allowed greater access to advanced technologies through increased foreign investment. A point emphasised by Hutschenreiter …

> " The role of FDI in technology transfer to China has been significant. Technological knowledge has been transferred through the import of intermediate and capital goods but also more directly through the transfer of technology, know-how and advanced management practises related to the implementation of FDI projects and the operation of foreign-invested firms. Especially before China's accession to the WTO, the approval of FDI projects was often made conditional to some disclosure of technology."[75]

4.3.2 Post 1978 Innovation Strategies

The first phase of policies aimed at raising technology and innovation occurred during 1976-77, therefore slightly pre-dating the launch of the 'open-door' period. The purpose of technology policy at that time was to modernize Chinese industry through major imports of overseas capital goods, the so-called 'foreign leap forward' (*Duiwai Yinjin* 对外引进), but the strategy was found to be wanting because of the shortage of foreign exchange to sustain high levels of expensive foreign imports.[76] The second phase of innovation strategy was promoted in the two decades following 1978. It was called the 'market for technology' (*Jishu Shichang* 技术市场) strategy, identifying FDI as the principal vehicle for technology transfer from the advanced countries.[77] This strategy has been, and continues to be, successful in raising the volume and value of FDI into China, and in the process changing the structure and efficiency of local enterprise. However, foreign companies have been reluctant to transfer the 'core' technologies … "Foreign firms in China typically perform some parts of the manufacturing process in China, with little technological innovation or product design … [thus]… foreign companies as a whole are currently less R&D intensive than domestic Chinese firms."[78]

Finally, the third phase of reform-biased Chinese leadership launched the ‘revitalising the nation through science and education’ (*Zhishi Jingji Yu Kejiao Xingguo* 知识经济与科教兴国) Policy in 1995. The point about this third phase of technological reform was that it signalled recognition by China that dependence on foreign technology for achieving technological sovereignty and competitiveness was no longer sustainable. China’s technology sovereignty could only be achieved via its own technological capabilities.

A major milestone in China gaining traction in technology development was the publication of the 2006 ‘Medium to Long-Term Plan for the Development of Science and Technology.’(*Guojia Zhongchangqi Kexue he Jishu Fazhan Gaihua Gangyao* 国家中长期科学和技术发展规划纲要).[79] The Plan established the objective, priorities and instruments that would be used in securing China’s short-term goal of becoming an ‘innovation-oriented’ society by the year 2020, and in the longer-term becoming a leading global innovation economy. The objectives to be to reached by 2020 are that …

> … “China’s R&D intensity will be increased to 2.5% of GDP (2.0% by 2010), innovation will contribute to 60% of economic growth, and China’s reliance on foreign technology will be reduced to below 30%, and overall, China will be among the top five countries worldwide in terms of key innovation output indicators … [this]…latest plan specifically emphasised the need to develop capabilities for ‘indigenous’ or ‘home-grown innovation’ with a view to creating the conditions for achieving a leading position in a number of S&T based industries.”[80]

China’s 2006 Technology Development Plan (2006-2020) emphasises that improving indigenous innovation capability is essential for adjusting economic structure and increasing competitiveness of the state.[81] The Plan refers to the concept of *Zi Zhu Chuang Xin*, which has four components: 1) genuinely original innovation; 2) integrated innovation; 3) the fusing together of existing technologies in new ways; and 4) ‘re-innovation’, involving the assimilation and improvement of imported technologies.[82]

China’s raised focus on indigenous technological development is significant in two respects: firstly, it appears to suggest that the country is pursuing its own brand of techno-nationalism, as per the Japan's approach during the course of its industrialisation process. However, in the pursuit of this goal, China will find it difficult to overcome the challenges faced by a globalising economic environment; and secondly, linked to the first point, the plan is interventionist in nature, marking a departure from the more typical reform process of a liberal, market-driven resource management model. Thus, the 2006 Plan identified 16 'special' projects for developing local capacity for critical technologies. These key technologies include core electronic devices, extremely large-scale integrated circuits, wideband wireless communications technology, advanced large-scale pressured-water reactors, the breeding of new transgenic biological varieties, innovational pharmaceutical products, and, importantly, giant aerospace technology.[83] The Plan also targeted advanced research in eight 'cutting-edge' technological areas, including biotechnology and advanced energy, marine, laser and aerospace technologies. The polices required for the implementation of the 2006 plan were also identified, and besides those that have already been discussed in this chapter, such as enhancement of civil-military education, the following issue, public funding for the absorption of imported technology was highlighted and will now be discussed in further detail.

Policies to support absorption of imported technology are numerous, but two contemporary initiatives are worthy of consideration, namely, the promotion of industrial clustering and enhanced integration into the global manufacturing and innovation production networks system.

4.3.3 Industrial and Technology Clusters

'Clusters' is a term which explains a set of close industrial relationships, and their development is a policy which over the last decade has attracted policymakers' attention.[84] As a concept, however, it has existed for generations. Clusters are an exciting development because they are believed to foster innovation through local knowledge spill-overs. They are particularly relevant to high technology industries, such as telecommunication and aerospace.[85] The commercial aerospace and aviation sectors have become very competitive and there has thus been a growing emphasis on cost reduction. One way of achieving this is for the civil aircraft OEMs to outsource to suppliers of subassemblies, including engines, structures, landing gear and avionics, with the OEMs focusing on their core competences of designing, integrating and marketing of aircraft. This has led to a rationalisation of the supply base around regional and international geographical areas of expertise. Academic writing on clusters distinguishes between ‘centripetal’ and ‘centrifugal’ forces; the former, explaining agglomerations of high-technology enterprise and the latter focusing on dispersion of industry across regions and nations.[86] Cluster analysis is linked to industrial agglomeration and arguably derives from Alfred Marshall’s seminal late 18^{th} and early 19^{th} century studies on the agglomeration of small-and medium-sized companies in the same or related industries.[87] A major finding from these studies is what has been termed ‘Marshallian externalities’. This is where technological leakages occur from the agglomeration of specialist suppliers, universities and research institutes. These knowledge spill-overs combined with the pool of specialised labour and other resources are a major explanation for the clustering of high-technology firms.

The notion of centripetal forces helps to explain the basis of domestic/regional industrial agglomeration. However, due to globalisation pressures, increasing academic attention is focusing on centrifugal forces. This is where open-trade and the search for cost and market efficiencies has promoted an international dispersion of industrial activity. This generates trans-national externalities, with production and services relocating to areas where there are locational efficiencies. Here, knowledge flows across borders via FDI and international strategic alliances and technology collaborations. Clearly, this process links to both Vernon’s international product life cycle thesis and to Akamatsu’s Flying Geese Model, as both these theories seek to explain the logic and dynamics of technology transfer based on an evolving comparative advantage.

Commercial aircraft production is a high value-added sector where scale, timing and government support for high tech. R&D are all critical considerations. For a country, such as China, which seeks to promote a knowledge economy it makes sense for policymakers to promote centripetal industrial policies and encourage domestic industrial clusters at major aircraft production centres, such as Tianjin.[88] At the same time, Western aircraft OEMs will be involved in the development of centrifugal forces, either voluntarily in the search for outsourcing opportunities or involuntarily through customer demands for offsetting investment. This entire process thus helps to explain the simultaneous interaction of both centripetal and centrifugal forces; that is the development of aviation industrial clusters comprising both domestic prime contractors, such as AVIC and international OEM prime and subcontractors, such as EADS and Roll-Royce. Aviation clusters, such those in Toulouse (France),[89] Warton (UK), Montreal (Canada), Nagoya (Japan) and at an incipient stage, Tianjin (China), reflect such developments.

4.3.4 Global Aerospace Networks

As a spur to indigenous technology development and innovation, the creation of industrial clusters has an important role to play. However, from the above discussion, what also appears to be important is the development of global production networks, particularly as applied to the commercial aircraft industry. Whilst Asia possesses no local equivalent to Boeing or Airbus, aviation companies in Japan, South Korea, China, Singapore, and to a lesser extent, Malaysia and Indonesia, have become important suppliers of components and subassembly work to the big foreign aviation OEMs. These Asian companies have been successful in their efforts to access the commercial aircraft industry's global supply chains for a number of reasons, including the supporting role of Asian government via a 'developmental' state regime, the high productivity and low cost advantages of Asian economies and the economic leverage of Asian airlines, including particularly Chinese and Singaporean, to influence aircraft development and pressure supply from domestic MRO and even production suppliers. The Chinese government's ownership of national airlines in the 1980s is an example of how a developmental state approach can influence global networking, in this instance, via the mandating of offsets. For example, in 1985, China agreed a deal with McDonnell Douglas to co-produce the MD-82 and MD-83 with Shanghai Aviation Industry Company, and later in 1990 to co-produce the MD-90.[90] Whilst these particular deals proved a failure, throughout the 1990s, China has become a significant subcontractor to both Boeing and Airbus. For instance, Shanghai Aviation Industry Company, Shenyang and Xian, manufactures horizontal stabilisers, fuselage components and vertical tails for the latest generation of 737.[91] Moreover, although Japan takes the lion's share of the subcontracts on the Boeing 787 Dreamliner, reaching

35% of value-added, China also has a share in the Boeing 787 global production network. For instance, Boeing has awarded a US$600mn contract to three Chinese companies to build the rudder, the leading edge of the vertical fin and wing-to-body fairings for the Dreamliner.[92] Similar networking arrangements have been agreed between China and Airbus: firstly, linked to China's huge 2005 purchase of 150 Airbus A320s is the opening of an assembly line in Tianjin; secondly, Airbus has committed to sourcing about 5% of the A350 from China.[93]

Technology development, then, is the final stage in the economic, industrial and technological development of countries. China is passaging through all these stages, and because of scale, cost and skill advantages has made impressive progress in building-up local technology capacity. It has relied heavily on FDI to access technology, but the belief is that with capacity will come capability. The development of the commercial aircraft industry provides on excellent case study of China's technology development. The fact is that a point has now been reached in the development of China's aviation industry, where the Chinese government has begun to invest heavily in the design and construction of a 'Chinese' commercial aircraft, and analysis of such indigenous industrialisation is the purpose of Chapter 5.

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[12] Mao Zedong, *Selected Works of Mao Zedong*, Vol. II, London (154), pp655-704.
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[16] Hsu, I, Op. Cit., p653.
[17] Hsu, I, Op. Cit., p654.
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[20] Hughes, T, and Luard, D, *The Economic Development of Communist China 1949-60,* London (1962), pp64-5.
[21] Hsu, I, Op. Cit., p655.
[22] Ibid., p657.
[23] Ibid., p662.
[24] See, Schrecker, J, *The Chinese Revolution in Historical Perspective*, Praeger (2004), pp23-4.
[25] "In general, the Stalinist model is a development plan that neglects the immediate needs of consumption and agriculture in favour of rapid industrial growth … it understands socialism as the complete nationalization of the economy and of tight central control, rather than … a blend of the best in *Fengjian* and *Junxian*, as a mixture of public and private, of centralization and decentralization." Schrecker, J, Op. Cit., p218-19.
[26] Ibid., p221
[27] It is reported that Mao … "insultingly characterised the Chinese people as 'poor and blank', so that success depended on the unique insights and wisdom of the Communist Party, and, in particular, on Mao himself." Schrecker, Op. Cit., p221.
[28] See, Macfarquhar, R, *The origins of the Cultural Revolution*, New York (1973).
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[30] The exact figures of the deaths are uncertain, ranging from a low of several million to a high of 40mn people. See, the detailed fr P254, Schrecker, J, Op. Cit., p225.
[31] Schrecker, J, Op. Cit., p225.
[32] Ibid., p225.
[33] A confidential government report stated that 655,237 were killed and 779,000 injured, see, Hsu, I, Op. Cit., p766.
[34] China's 1950 entry into the Korea War led US President Truman to freeze US$80.5m of Chinese assets in US, with China responding in like kind. See Hsu, I. Op. Cit., p799.

[35] An example of a regional escapade would be China's 1979 invasion of Vietnam to "teach the Vietnamese some necessary lessons."
[36] The Four Modernisations: agriculture; industry; science and technology; and national defence (Eleventh Congress, 1977) – the aim being to transform China into a modern state by the year 2000, see Hsu, Op. Cit., p803.
[37] Hsu, I, Op. Cit., p803.
[38] People's Daily (9 March, 1978): Cited in Hsu, Op. Cit., p804.
[39] Hsu, Op. Cit., p813; original source: Liang Hsiao, 'The Yang Wu Movement and the Slavish Comprador Philosophy', *Historical Research*, 5 (20 October, 1975).
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[52] Ibid., p363.
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[54] Naughton, B, Op. Cit., p364.
[55] See, Hu, A, Jefferson, G and Qian J, 'R&D and Technology Transfer: Firm-level Evidence from Chinese Industry', *Review of Economics and Statistics* (November 2005), Vol,87, No 4,pp780-86.
[56] See, Fisher-Vanden, K and Jefferson, G 'Technology Diversity and Development: Evidence from China's Industrial Enterprises', *Dartmouth College MS (205):* cited in Naughton, B, Op. Cit., p364
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[59] Naughton, B, Op. Cit., p379.
[60] Ibid., p379.
[61] Ibid., p382.
[62] *UNCTAD* http://www.unctad.org/Templates/webflyer.asp?docid=9439&intItemID=1528&lang=1.
[63] Naughton, B, Op. Cit., p409.
[64] News from Xinhua Net downloaded from http://news.xinhuanet.com/ziliao/2003-01/23/content_704704.htm (28 April, 2009).
[65] As discussed in Chapter 2, short-term economic multiplier effects will come from counterpurchase policy and long-term technology transfer will come through technology offsets.
[66] Liu Huaqing, speech by former Chinese Politburo Standing Committee member and Vice-Chairman of the Central Military Committee (1992).
[67] *China's Science and Technology Development*, http://edu.cn/20010101/22309.shtml.
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[69] Ibid.

[70] See, International Development Research Centre (IDRC-Canada) and the State Science and Technology Commission (PRC), *A Decade of Reform: Science and Technology Policy in China*, Chapter 1 General Findings, IDRC (1997).
[71] Zhu Lilan, (ed) *Science and Education for a Prosperous China*, CPC Central Party School, (1995), Chinese Version.
[72] Ibid.
[73] Naughton, B, Op. Cit., p366. The author makes the point that post-1999 policies enabled technological development because they abandoned the ideological baggage that had inhibited technological development up to that time. Importantly, 'National Industry' was redefined to include foreign-invested firms.
[74] Naughton, B, Op. Cit., p366.
[75] Hutschenreiter, G, and Zhang, G, 'China's Quest for Innovation-Driven, Growth - The Policy Dimension', *Journal of Industry, Competition and Trade*, vol. 7(3), 2007, p246.
[76] Ibid., p248.
[77] Ibid., p248. This strategy was linked to the creation of Special Economic Zone's discussed earlier in this Chapter.
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[83] *State Council, China National Medium and long-term Science and Technology Development Plan* 2006-20. Op. Cit.
[84] Clusters represent a geographical concentration of interconnected business, suppliers and associated institutions in a particular field, promoting increases in productivity and innovation.
[85] Niosi, J., Zhegu, M. (2005), 'Aerospace clusters: local or global knowledge spillovers?'*Industry and Innovation*, Vol. 12.
[86] See, Aerospace Cluster: 'Aerospace clusters: local or global knowledge spillovers?' downloaded from www.er.uqam.ca/nobel/r21010/document/niosizhegu.pdf (27 April 2009).
[87] See, Meardon, S, 'Modelling Agglomeration and Dispersion in City and Country: G. Myrdal, F. Perroux and the New Geography', *American Journal of Economics and Sociology*, Vol. 60, No 1 (January 2001), pp25-57.
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[90] Goldstein, A. 'The Political Economy of Industrial Policy in China: The case of Aircraft Manufacturing', *Journal of Chinese Economic and Business Studies*, Vol. 4 No 3 (November, 2006), p26.
[91] *Boeing in China*: http://www.boeing.com/companyoffices/aboutus/boechina.html.
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Chapter 5 Case Study of China’s Aviation Industry

5.1 Aerospace as a Strategic Industry

Aerospace, and within this sector, aviation, is viewed by most country government’s across the world as a strategic industry: it has broad implications for 'national power' and is therefore strongly correlated with national and political interests.[1] Firstly, it is a 'dual-use' industry, so that its growth and technological deepening not only impacts on civil commercial aerospace capability but also contributes to the development of the military aerospace sector. The EU considers aerospace a strategic industry because it is viewed as a technology driver.[2] Necessarily, the host country government must develop the technology level of its 'infant' local aerospace prime contractors, but these primes will literately act as an engine of growth, especially to 'pull' along subcontractor high technology firms. Moreover, the aerospace industry fulfills the criteria for sectors that act as growth poles within the economy. Thus, in India, for instance, the aerospace sector is considered by the New Delhi government to be amongst the most important of the 16 defined priority development sectors.[3] According to India's Finance Minister, Yashwant Sinha, the country is focusing on sectors which are important, nationally, like infrastructure and core industries, where exports take place or where technology is needed in its foreign investment policy.[4] Thus, India considers aerospace a tool for economic development with a significant role in national security and international relations, representing one of the most significant technological influences of our time.[5] Equally, China considers its aerospace sector as 'part of a larger technological transformation.'[6] At least partially, this relates to the ‘Revolution in Military Affairs’ that is taking place in China.[7] China is concerned with the development of the domestic aerospace sector, because it is linked to military modernization, infrastructural development and international prestige.[8] Through its aerospace activities, China plans to meet the growing demands of economic construction, national security, and science and technology development.[9] Aerospace is viewed as an integral part of the state's comprehensive development strategy, described by President Hu as a ... “significant symbol of the nation's strength.”[10] Moreover, within the broad field of aerospace, an important point to note is that China is one of the few countries in the world that has the economic potential to sustain a home-grown aviation industry. By reference to Table 5.1, China has an estimated requirement for 2,639 passenger aircraft by 2025; this makes it the world's biggest emerging aviation market, and in the next 20 years will see the country become the second largest market in terms of demand for passenger aircraft after the US.[11] From the demand perspective alone, it therefore makes economic sense for China to develop its own commercial aviation industry. Indeed, according to Dougan, China wants self-sufficiency in manufacturing civil aircraft,[12] elaborating his argument, thus:

> ... “If China possessed a large and effective air transport service network, and more importantly, could supply this network with equipment made domestically, it would mean the country could become an economic and technological global power able to compete worldwide in a range of other associated industries and 'high-tech' product groups. The possession of an effective civil aviation industry is thus exactly the type of broad-based 'hi-tech' industry that China's leaders desperately want to possess, for its own sake, and also …[because of what it signals]… about the country's overall level of technological and economic development. For these military/strategic, economic and emotive reasons, civil aviation is important to the Chinese government.”[13]

Given this contextual backdrop, then, the purpose of this chapter is to critically analyze the development of China's aviation industry. The first section surveys the origins and early development of the industry, particularly its linkages with overseas collaborators. The accelerated build-up of domestic aviation capacity during the post-1978 reform period will then be explored. This provides the foundation for an in-depth analysis of the degree to which indigenous industrialization has been achieved. After a broad evaluation of the present economic status of the aviation industry, its technological development will be analysed according to the three performance metrics, value-added, technological innovation and the creation of local supply chains.

5.2 1st Phase: China's Early Aircraft Building Pretensions

The Chinese have long cherished an ambition to fly. Almost from the beginning of time, Chinese fairy tales narrated stories of the splendour of flying, perhaps akin to the

West's fables of Peter Pan.[14] The first actual attempt at flight in China can be traced back to the Seventh Century BC when the famous craftsman Gong Shubon flew a Magpie made from bamboo and wood.[15] Later, in AD19, as recorded in the 'history of the Han Dynasty - the Biography of Wang Mang', a man was witnessed flying dozens of metres with two huge bird wings, and feathers all over his body; this being the earliest recorded flying/gliding experiment using human force.[16] Around the same time, some two thousand years ago, China invented kites, and these were regularly used for military purposes, including aerial signal lights and manned reconnaissance from AD420.[17] In AD559, a man glided downwards from a high place using a kite, suggesting that flight could be realized with the use of man-made fixed wings, a fact of some significance for the later invention of aircraft.[18] Other ancient Chinese aerial vehicles included hot air balloons and bamboo dragonfly;[19] the latter being called the 'Chinese Gyro' by European scholars, representing the origins of the present-day lifting propeller.[20]

The modern era of Chinese aviation really began during the Qing dynasty when in 1887 Hua Hengfong successfully flew a manned hydrogen balloon.[21] However, the momentous event occurred in 1910 when the Qing government established an aircraft manufacturing plant at Nanyuan, a southern suburb of Beijing, with the first aircraft flying the following year.[22] Following the 1911 'revolution' that overthrew the Qing Dynasty, the famous Dr Su Yatsen promoted the expression ... "saving the nation with aviation.[23] This phase acted as clarion call around which resources were channeled to create a Chinese capability in aviation. In 1911, Dr Sun established the country's first Air Force. He called on overseas Chinese to return and engage in flying skills along with the relevant technologies of manufacturing. One of the returning Chinese was Feng Ru, who successfully designed and produced aircraft in the US, bringing two of his designs back to China.[24] Another returnee was Tan Gen, who was one of the earliest designers and producers of water-based aeroplanes. His return in 1915 led to the establishment of the Guandong Aviation College.[25] Yet another Chinese citizen, Yang Xianyi, a graduate from an aviation college in the US, supervised the construction of a two-seater biplane reconnaissance-trainer in 1923.[26]

A major theme in aircraft production studies is the close relationship between military and civil aviation activities and this was the course taken in the early development of China's aircraft industry. Thus, after the founding of the Chinese Republic in 1911, the Beijing government constructed an aircraft factory in 1912, and later a similar establishment in Qinghe, Beijing. Somewhat later, a Naval Aircraft Engineering Department in Fujian Province designed and manufactured a folded-wing reconnaissance aircraft.[27]

With the passage of time, the Chinese government began to build-up aircraft production capacity through the use of technology transfer. There were two approaches: one was through hard transfer, and the other through soft. Examining, firstly, China's promotion of hard technology transfer, the starting point was really the Kuomintang government's established aircraft repair factories at Hangzhou, Shanghai, Nanjing and Wuchang in 1934 and 1935 by using foreign investment, materials, equipment and technology.[28] Through these means, copy production and aircraft assembly was begun. For instance, the central Hangzhou Aircraft Factory, a joint-venture with a US partner, copied and assembled about 300 US aircraft across an eight-year period.[29] Similarly, the Central Nanchang Aircraft Factory was another joint-venture aerospace enterprise established with four Italian companies for the license production of Italian aircraft. However, the factory was relocated to Nanchuan after Japanese bombing and started copy production of Russian 'pursuit' aircraft as well as basic gliders.[30] There was also indigenous design of the Zhong Yun-1 and Zhong Yun-2 transports, though neither entered into batch production.[31] During the War of Resistance (1937) against the Japanese invasion, there was much US assistance given to China, including training in aircraft design for local technological personnel and the production of American piston engines.

Soft technology transfer came in the form of Chinese engineering scholars going abroad for training and then returning to China to contribute to the aviation industry's development. Thus, one of the many Chinese students that went overseas in the 1930s to study aviation was Wang Zhu, who worked as an aircraft designer at the US Boeing Company.[32] He returned to develop the Chinese aircraft industry, as did Qi Xuesen, co-inventor of the Karman-Tsien mathematical formula used in the dynamic design of high subsonic aircraft. Moreover, throughout the 1930s, aviation courses were started at Chinese universities, such that by 1949 the numbers of Chinese aviation graduates had reached about one thousand.[33]

Thus, by the time of China's Independence in 1949, a 'sovereign' aircraft industry had not been established, but the beginnings of capacity and a skill-base had been put in place. The problem of dependence on overseas supply of parts and technology for both civil and military aircraft had begun to be recognised. However, China faced a lack of capital, had minimal aerospace skills, no supporting infrastructure to support aircraft development, and, finally the War of Resistance against Japan had seriously weakened the already fragile local aircraft industry’s foundations.

5.3 2nd Phase: Early Post-Independence Sino-Soviet Collaboration

Creating a national aviation industry was viewed immediately after Independence as an important step, because as a strategic industry, it would benefit both economic development and national defence capability. Chairman Mao Zedong and Premier Zhou Enlai were concerned with the fast construction of an aviation industry, not least because the People's Liberation Army Air Force (PLAAF) was established in November 1949 and just a year later saw the outbreak of the Korean War and US forces stationed close to the Chinese border. Korean hostilities gave greater urgency to the development of aviation capability and in December 1950, very soon after the war had begun, the policy decision was taken that China should quickly move to develop a national aviation industry. This decision led to an aphorism based on the practicalities of Chinese culture ... “from repair to copy production, and from copy production to design and manufacturing.” (*Cong Xiuli Dao Fangzhi he Zixing Seji Zhizao* 从修理到仿制和自行设计制造).[34]

Cooperation with the Soviet Union was meant to be the catalyst by which China's aviation industry would literally 'get off the ground.' The partnership began when a Chinese delegation visited the USSR in January 1951 to seek technical assistance. This resulted in October 1951 in the signing of an ‘Agreement for USSR to Render Technical Assistance’. Somewhat earlier, in April 1951, China set-up the Bureau of

Aviation Industry under the Ministry of Heavy Industry. Wasting no time, in the September of that year, the Ministry took over 18 aerospace factories from the Air Force, and from a zero baseline, the bureau now had around 10,000 workers under its control.[35] The 18 factories were essentially focused on repair services and Premier Zhou's direction was that ... “When the repair factory is designed certain considerations should be given to the arrangement and planning for transferring it to manufacturing in the future.”[36] Accordingly, a follow-up agreement was signed with the USSR in 1953 to create 13 'backbone' aviation factories in China focusing on the production of aircraft, aeroengines, and air borne equipment using high-premium machining equipment.[37] Necessarily, the Soviet Union would supply the heavy machinery and funding was allocated in China's First Five-Year Plan. The Plan was far-reaching in the sense of ensuring the financial and manpower resources to procure 'completely knocked down' aircraft kits shipped from the Soviet Union. As in the 1930s, the policy-thrust was once again aimed at the build-up a cadre of highly skilled Chinese aeronautical engineers. For instance, Liu Xiao Peng, who had trained in Britain, became a key aircraft designer.[38] He was heavily involved in the development of China's first generation of attack aircraft. Another British trained aeronautical engineer and a member of the Royal Aeronautical Society, Shen Yuan, was appointed Vice-Principal of the Beijing Institute of Aeronautical and Astronautics.[39] Central Planning was critical in creating the skilled human resources: skilled technical staff were transferred from other sectors to the emerging aviation industry; around 800 Soviet experts were transferred to China as part of the Sino-Soviet agreement, and many were involved in training Chinese personnel; and some 350 Chinese trainee engineers were sent to the Soviet Union to study astronautics during the ten years of this collaborative effort.[40] Additionally, three aviation universities were established in 1952, along with large numbers of associated technical colleges in the years that followed.

Sino-Soviet collaboration was important in ‘kick-starting’ China's aviation industry. It led to the final stage in the development process, that of manufacturing, albeit that the original designs were Soviet. For instance, in 1954 the Yak-18 primary trainer, with the Chinese name, CJ-5, rolled off the production lines at the Nanchang Aircraft Factory.[41] Two years later, one of the most advanced fighters in the world at that time, the MIG-17 began to be produced at the Shenyang Aircraft Factory under the Chinese name, J-5, China then became one of the few countries in the world with the capacity to produce jet aircraft; [42] however, many of the high-technology systems still had to be imported from the Soviet Union. The Nanyang Aircraft Factory became an important production centre in China's expanding aviation industry, producing the country's first civil aircraft, the Y-5, derived from the Russian AN-2 multi-purpose small transport plane.[43] By 1960, China has established an impressive manufacturing capacity. In relatively short space of time, the industry has produced around 1,086 aircraft for the PLAAF, including its first jet fighter trainer, the JJ-1.[44] The beginnings of a R&D capability had also been constructed, including six Research Institutes, three Design Institutes and 19 Research and Design offices covering flight testing, aerodynamics and aircraft accessories.[45] There is no doubt China's indigenisation efforts began in the 1950s, but it was almost totally dependent on the massive inflow of skilled manpower, technical assistance and technology transferred from the Soviet Union.

By the late 1960s, however, the Sino-Soviet partnership was over. Political and ideological differences led to a complete breakdown in relations and the total withdrawal of Soviet aircraft design and building assistance from China. The challenge was immense. China was now technologically isolated, given that it was also continuing to suffer a Western embargo on aerospace technology from the time of the Korean War. The government's response was to pursue a 'forced' policy of self-reliance and for aviation this meant ... ‘adjustment, consolidation, replenishment and improvement’ (*Tiaozheng Gonggu Chongshi Tigao* 调整，巩固，充实，提高).[46]. The reality of this edict was that aircraft production activity was ‘dumbed-down’ to focus on spares production, maintenance, and modification and refinement of existing Soviet-designed aircraft.[47] The push for self-reliant development was not abandoned, however, now being managed by the 1963 Ministry of Aviation Industry and some degree of success was achieved in subsequent years. The J-6 fighter, the J-5A all-weather subsonic fighter, and the high-attitude high-speed J-7 fighter, began to be produced across 1964-66; indeed, around 1,055 aircraft were produced during this period.[48] The process of adapting from the Soviet withdrawal seemed to be working well, but then China had to face the disruptive consequences of the 1966-76 Cultural Revolution. Much of disruption came from a reduction in trained technical personnel, caused by the Revolution's negative impact on education and training. Moreover, another unrelated problem faced by the aircraft industry during this period was the 'Third Front' policy, involving the shift of aviation production inland towards the mountainous regions. In case of war, aircraft factories had to be located well away from the coastal areas, but their reconstruction in remote underdeveloped regions meant that scarce capital was wasted.

5.4 3rd Phase: Development of Aviation Capability through Western Cooperation

Following the disruption of the 1960s, and early 1970s, a significant event occurred in 1975, the beginnings of Western technological cooperation in the aviation sector. This occurred with China's purchase of Britain's Rolls-Royce Spey engine.[49] It filled a gap in turbofan engines for the emerging Chinese commercial aviation industry, and had far-reaching implications for Western aerospace contractor participation in the development of China's civil aviation industry. The next major development milestone was the 1978 Third Plenary Session of the Eleventh Congress of the Communist Party, and its advocating of policies for ... "reorganisation, reform adjustment and improvement" (*Tiaozheng, Gaige, Zhengdun, Tigao*) along with the celebrated 'opening-up' of China with the outside world.[50] The Ministry of Aviation's main focus was on reorganization to achieve quality through technology transfer, advancing the aphorism … 'scientific research going ahead of the rest.'[51]

In powering forward the development of China's aviation industry, three strategies were adopted, namely: self-reliant aircraft construction; subcontracting activity, most notably through offsets; promotion of international joint-ventures; alongside a general welcoming approach towards FDI in China's growing aviation sector. Although these strategies are distinct, they are not discrete, in the sense that they overlap and are not sequential in their impact.

5.4.1 Self-Reliant Aviation Development

China was impatient to achieve its aviation ambitions and was keen to develop commercial aircraft capacity, but it would first have to be 'weaned' from almost total development a military production. In fact, a premature start to the development of commercial aircraft production had begun in 1973 with the government approval of the Y-10 project. The development of this 'large' airliner was assigned to the Shanghai Aircraft and Design Institute. The design of the four-engine large-haul aircraft took two years to complete. A full size aircraft destructive test was carried out in 1978 and the first fight of the Y-10 took place in September 1980. Two prototypes were built and the 121 fight trials took in every major Chinese airport, including Beijing, Hefei, Harbin, Urumqi and Chengdu/Lhasa.[52] Then, suddenly, the project was terminated due to cost and market limitations.[53] Thus, whilst China had demonstrated that it was capable of undertaking basic aircraft manufacturing, it still had some way to go before it could secure the commercial expertise to produce commercial airliners. For this to happen, particularly the need to produce high quality, safety premium commercial aircraft, it would have to divert scarce resources away from military aircraft production. Accordingly, the way forward was deemed to be civil-military integration and conversion. Deng Xiaoping's 1978 maxim was … "Combine the military and civil, combine peace and war, give priority to military products, let the civil support the military, (*Junmin Jiehe, Yimin Yangjun* 军民结合，以民养军).'"[54]

Thus, from 1979 onwards the policy thrust was to transform the near total military production structure to joint military and civil production systems. Via this approach, the costs of creating commercial aviation production capacity would be reduced through obtaining beneficial military spin-offs. It was also a possible lever for obtaining important aviation technologies from overseas aviation contractors that could then be 'spun-on' from the commercial sector into the military aerospace industries. Thus, although the 'military first' policy-emphasis was maintained, a boost was given to commercial aircraft ventures. Because civil-military integration meant that the sharing of fixed cost technologies and facilities could be enjoyed, including common technologies, processes, labour, equipment materials and facilities, R&D, manufacturing and maintenance operations, China's commitment to succeed was there and increasingly the resources were available to support the industry's growth, which was dramatic. In 1978, the output value of China's civil aviation sector was just 6.5% of total value, but by 1986 this had increased to 61.2% of the aerospace sector's total output value.[55] Although still on a small-scale, local civil aircraft were nevertheless, beginning to enter the market. This included the 50-seat Y-7 and 19-seat Y-12 passenger aircraft; the latter being exported to 18 countries after obtaining British CAA and US FAA airworthiness certificates.[56] Moreover, license-production of Western products began to play a part in the development of the industry; for instance, in the production of the Z-8 and Z-9 large multi-purpose and French Dolphin helicopters, respectively.[57] On the conversion side, with defence production beginning to decline, the push was to diversify and convert military capacity to non-aviation production. These civil goods covered the spectrum, typically including automobiles, motorcycles, refrigerators, and textile machinery, accounting for about 75% of sales in 1996.[58] It has also been reported that more than 2,500 defence technologies have been released for civil use since the early 1980s.[59]

5.4.2 Subcontracting through offsets

General speaking this has regard to licensed production of foreign OEM aircraft, parts and subassemblies. This developed to be an important aspect of China's aircraft industry development strategy, given growth of domestic air passenger transport, and therefore of commercial aircraft, provided the authorities with the opportunity to demand work transfer packages for China's aircraft factories tied to the big volume procurement of foreign aircraft. These offset deals led the way to hundreds of subcontract deals being signed with numerous overseas OEMs, including those from the US, UK, Germany, France and Canada. It has been estimated that by the latter part of the 1990s these subcontracts amounted to over US$750m, of which US$617m related to the production of aircraft spares and US$133m to engine components.[60] These subcontracting programmes included several with the US company, Boeing; namely Shanghai Aviation Industry -737 horizontal stabilisers; Xi'an Aircraft Manufacture -737 vertical fins and 747 railing edge ribs; Shenyang Aircraft Corporation -737 tail sections and 757 cargo doors; and the Hongyuan Forging and Casting Factory - Titanium alloy Forgings.[61] Another US company, Lockheed, subcontracted work to the Shanxi Aircraft

Company, linked to its modification contract on China's Y-8 medium transport aircraft.[62] BAe, the British Company, subcontracted the landing gear for the BAe-146 to the Harbin Aircraft Factory and the rudder assemblies to the Shenyang Aircraft Company. Since 1982, the Canadian company, shorts, has subcontracted cabin doors, freight doors and service doors on its SD3 series aircraft to Harbin Aircraft Factory.[63]

In the aero-engine field, General Electric (US) subcontracted work to Chinese aerospace companies on critical engine parts, such as the compressor and turbine disks and rear shaft high-pressure turbines for the (French-US) CFM-56 engine.[64] Subcontract work was also undertaken for the European Airbus Industries by the Xi'an and Shenyang Aircraft Companies, including emergency exit doors for the A320, service doors for the A300/A310 series, and in 2001, the 100th A320 rear- boarding gate was delivered by Chengdu Aircraft Industrial Corporation.[65]

The subcontracting mechanism facilitated by offsets (China's purchases of foreign passenger aircraft) has proved a successful vehicle for the transfer of technology and work packages. Subcontracts also necessitated Chinese manufacturers using advanced management and production techniques and implementing high-level quality assurance procedures. There is thus no doubt that this approach has contributed to China's commercial aviation capabilities, but there is evidence to suggest that the technological nature and degree of value-added has been at a low-level.(see section 5.7.1) Therefore, the Chinese authorities introduced a complementary development strategy based on the need to advance local capability through foreign joint venture projects.

5.4.3 Promotion of International Joint-Venture Aviation Projects

From a programme of restructuring that took place in 1993, the Aviation Industries of China (AVIC) became the 'core' enterprise within China's aviation aerospace sector. It was, and is, a huge state-owned company responsible for developing and producing military and civil aircraft, missile, engines and an array of civil commercial consumer goods. Within AVIC, defence accounted for 60-70% of aerospace output, but AVIC had plans to change this ratio in favour of civil aerospace.[66] A three-pronged strategy was agreed that would eventually lead to China becoming self-sufficient in the development and production of large aircraft by 2010.[67] The three strategic development stages are:

Stage 1: Licensed production of major parts of airframes

Stage 2: Development and production of a 100-seat regional jet, developing the capacity and competence in the areas of quality control and certification

Stage 3: Indigenous design and production of a 180-seater passenger jet by 2010.[68]

Stage 1 developments have already been discussed, including the successful development of Y-7 and Y-12 aircraft, based on the import of foreign technology. China's 1975 license-production of the Roll-Royce Spey MK202 engine was another early manifestation of this strategic approach, as was also the licensed production of the 50 Dolphin Helicopters from the French company Aerospatiale. Licensed production of the helicopter's Ariel 1C engines was also agreed.[69]

Whilst licensed production of modern foreign parts, subassemblies and the fabrication of sections of the airframe were certainly important steps in gaining technological capacity, the early 1980's failure of the local Y-10 project convinced the authorities that the development of a medium to large aircraft was crucial for the growth of China's aviation industry. As a consequence, China Aero-Technology Import Export Corporation (CATIC) and Germany's MBB reached agreement on the joint development of a 75-seater passenger aircraft in 1988, with CATIC holding 20% of the joint company's shares.[70] More than 200 Chinese aeronautical engineers were sent to Hamburg for training, but shortly afterwards the project was prematurely ended without any aircraft being built.[71] Germany's industrial reorganisation of MBB was a major reason for this projects' cancellation. However, China's approach to its Stage 2 strategic goal was unique. The development of a 100-seat regional aircraft would be the 'reverse' of the normal path of design, development, and certification through to market, manufacture, delivery and support.[72] The project would begin with final assembly capability, then expanding to include fabrication of components, creating the demand for local suppliers and finishing with design and certification of a local indigenous aircraft. The MD-82 co-production programme with US company McDonnell Douglas (MD) would be the first test of this strategy. The plan was to start with final assemblies and major subassembly kits, and then to complete manufacture, supported by full technology transfer. MD transferred major subassemblies to Shanghai for final assembly, including the nose section, complete empennage and fuselage skin sections. Blueprints were also transferred, with the US company assisting with FAA certification on the basis that the designs, parts, indeed, the entire aircraft were identical to its US-built counter-part, except that it was ‘made in China’. The programme produced 25 MD-82 aircraft at the rate of eight units per year.[73] Major subcontracts were given to two Chinese aerospace companies: 10 went to the Shanghai Aviation Industry and with the Chengdu Aircraft Company.[74] Some complex assemblies were produced like the nose and cargo doors, but they did not substantially increase industrial capacity as they represented just 15% of the airframe.[75] Nevertheless, the production of the MD-82 was held be to a great success, laying solid foundations for joint development of medium-sized aircraft with foreign assistance.[76] On this basis, the Chinese agreed to partner on the local development of the next-generation passenger aircraft, the MD-90.

The MD-90 plan was to increase local production, and additional work was allocated to Chinese aircraft companies: Shanghai increased its share of subassemblies production, becoming responsible for final assembly; Chengdu built the nose and the entrance and airstair doors; Shenyang fabricated and assembled the empennage and all electrical wiring for the aircraft; and Xi’an fabricated and assembled the fuselage section and the wingbox. MD supplied all the machine tools, and Chinese aviation teams went to MD’s long Beach, California, factory, and the entire programme, including buybacks, was agreed in record time in 1993.[77] Thereafter, however, the project was affected by problems. Firstly, the aircraft had to be modified, due to poor runway conditions at China’s major airports.[78] Then, by the time the extensive modifications to the landing gear were complete, infrastructural improvements at the airports had made the modifications unnecessary. Secondly, when the MD-82 programme was first introduced into China in the early 1980s, the country was still essentially a communist, centrally planned economy and the decision to buy the aircraft was taken by the central authorities. By contrast, in the early to mid-1990s, China’s domestic airlines were free, under a more liberalised economic regime, to make their own procurement decisions. The decision by most of the airlines was not to buy the MD-90, but, instead Boeing and

Airbus aircraft.[79] There were thus no customers for 20 MD-90 aircraft in assembly kits in Chinese warehouses.[80] Finally, in April 1997, it was announced that Boeing was taking over McDonnell Douglas, further delaying decision-making and putting the whole project in jeopardy. Eventually, in mid-1999, the MD-90 project was terminated at great expense to all parties, seriously delaying China's plans to establish an indigenous commercial aviation capability.

In parallel with MD-90 fiasco, China sought to promote a separate US$2bn aircraft project built around Asian cooperation and supported by Western aviation OEMs. This early 1990's project was called the Asian Express 100 - a 100-seater aircraft that would be developed through a risk-sharing partnership. Potential overseas partners had in sight the revenue-earning benefits of being linked into the fast growing Chinese civil aircraft market. Thus, there was much foreign interest from Western aircraft prime-contractors, including Boeing, McDonnell Douglas, DASA, Samsung and Singapore Technologies to tie-up with the Chinese partner, AVIC. In addition, overseas' 'super' subcontractors, such as Rolls-Royce, General Electric, SNECMA, Messier-Dowty and Aircraft Brake Systems, were positioning themselves to access this project through subcontract work or as joint-venture partners as parts of the AVIC's supply chain. The Asian Express 100 aircraft project was another example of China's efforts to close the aviation technology gap with the West. The goal of self-sufficiency was the driver, but the country's desire to access advanced technology posed a problem for the advancement of this project.[81] In the end, Airbus and the Singapore Technologies Group were favourites to lead on the joint design and manufacture of this Asian Express 100. However, the foreign companies grew increasingly concerned with China's insistence that it should be responsible for systems integration, despite its clear lack of capabilities in this area.[82] As a consequence, yet again, a Chinese collaborative commercial aircraft project was aborted.

5.4.4 Reviving the Dream: Developing Chinese Commercial Aircraft

In 1993, the 3rd strategic stage in the development of China's commercial aviation industry was focused on indigenous design and production. This was when the Eighth National People's Congress put the entire aviation industry under AVIC control, and became the growth pole of China's aviation development efforts. Initially AVIC was weighed down with an excessive payroll and diversified product portfolio that lacked coherence and focus. Gradually, however, it rationalised and raised efficiency, increasingly looking a viable Chinese company to help achieve China's aviation goals. Aside from several rounds of re-structuring, the aerospace and aircraft manufacturing sectors began to receive priority status in the context of China's science and technology programme, attracting research and training education resources to reinforce design and support capabilities. In the Tenth Five-Year Plan (2001-2005) more than RMB5bn was spent on R&D in the field of commercial aerospace technology compared to RMB1.7bn in the Nineth Plan.[83] Moreover, China-based scholars now account for a very substantial share of paper submissions to leading aerospace journals.[84]

Due to these additional resources supporting aviation development, the target date for an indigenous aircraft was set at 2010, but this seemed wildly optimistic, given the difficulties China had faced in achieving its second strategic goal of developing a 100-seater regional jet. As a result, the planning process began to change to reflect these realities. Instead of three 'sequential' strategic stages, the development of China's commercial aviation sector would now be via the 'simultaneous' pursuit of all three stages: subcontract work, primarily through offsetting technology transfer, though also through competitive contracts, if possible; collaborative production with foreign civil aerospace prime contractors, particularly in respect to the (elusive) long-planned regional 100-seater aircraft; and, the continued goal of indigenous design and manufacture of a large passenger aircraft.

Commitment and consolidation were to take the industry into the 21st century, and access to technology would continue to emphasize cooperation with Western OEMs, but increasingly, investment funds would be directed towards raising local aviation-related research, design, development, systems integration and support capabilities. China was undeterred by its succession of failed international cooperation ventures and would seek to continue its promotion of such projects. Positive changes in China's domestic economic environment were leading to a greater willingness of foreign aviation companies to invest in China. This was partly to do with China's 2002 membership of the WTO,[85] and its associated determination to liberalise, incentivize and commercialise China's economy; it was also partly linked to China's annual double-digit economic growth, and the consequent massive expansion of demand for air travel; and partly to do, finally, with China's recognition that it needed equal 'partnership' with overseas companies rather than unbalanced relationships to forge long-term mutually beneficial and, most importantly, sustainable industrial undertakings. There were, thus, rising numbers of Western aerospace companies keen to engage with China, not just through sale, but through offsets, FDI and joint-ventures. The conducive business environment, combined with China's massive projected demand for commercial aircraft, led to a step-change in the West's involvement in the rapidly expanding Chinese aviation industry. From 2000 onwards, major new manufacturing ventures were started in China, and these spanned the spectrum of international prime contractors, from Airbus and Boeing, to Brazil's Embraer and Canada's Bombardier. Following the primes, came the world's leading aircraft sub-contractors, including Roll-Royce, General Electric and Safran. The development foundations were at last being laid, and indigenisation finally becoming realisable. The next section examines the nature and growth of this stage of aviation development, setting the stage for subsequent analysis of the 'depth' of local technological development.

5.5 New Millennium: The 'Long March' (*Changzheng*) Towards Indigenous Design and Production

As mentioned earlier, AVIC is at the heart of China's efforts to indigenise its aviation industry. Although China's aviation sector began formally to emerge in 1951, with the requirement to produce military aircraft, the recognition of the importance of commercial aircraft production had to wait until 1963. In that year, the Ministry of Aviation Industry was created to manage the development of the aircraft industry, Thirty years later, in 1993, socialist ownership of aircraft production was replaced by the creation of a joint-stock company, the Aviation Industries of China (AVIC). In a policy initiative to introduce greater focus and commercial efficiency into this huge industrial conglomerate the enterprise was split in July 1999 into AVIC I and AVIC II. The restructuring was driven by global shifts in economic policymaking and emphasis placed on competition and the search for core competences. China's policy-makers had determined that AVIC I and AVIC II would henceforth both cooperate and compete.

However, the split enterprises remained huge by international standards. AVIC I possessed 53 large- and medium-sized industrial establishments, 31 research institutes, and 20 specialised companies and institutions.[86] Employing 230,000 workers, it produced a wide assortment of military and commercial aircraft, including fighter bombers, trainers and transports.[87] For non-aero products, more than 3,000 different types of products in eight major categories had been developed, including gas turbines, automobiles, motorcycles, refrigerators, machinery and environmental protection, equipment.[88] AVIC I had 45,000 other staff employed in the research institutes, with company total assets valued at RMB150bn.[89] AVIC II was similarly huge, employing 210,000 staff and controlling 64 large- and medium-sized industrial enterprises and three research institutes, with total assets of RMB78bn.[90] AVIC II was focused on the development and production of, again, both military and civil aircraft, helicopters, trainers and UAVs.[91] AVIC II has produced more than 6,800 aircraft (including 800 helicopters), 26,000 aeroengines and 10,000 tactical missiles.[92] Co-developed/produced projects, include the K8-jet trainer with Pakistan, the EC 120 helicopter with France and Singapore, and the ERJ-145 aircraft with Brazil. AVIC II's non-aero business includes automobiles, motorcycles, related engines and parts, gas turbines and wind power electricity generating equipment.[93] With respect to automobile production AVIC II has become a major development and production base in China. Its annual output is now accounting for one-tenth of national automobile production.[94]

Self-sufficiency remained an important strategic objective of this restructuring, but a principal secondary objective was to make the industry more flexible, specialised and competitive. At that time, however, the split in industrial structure moved against the global tide of emphasising competency through scale and merger.

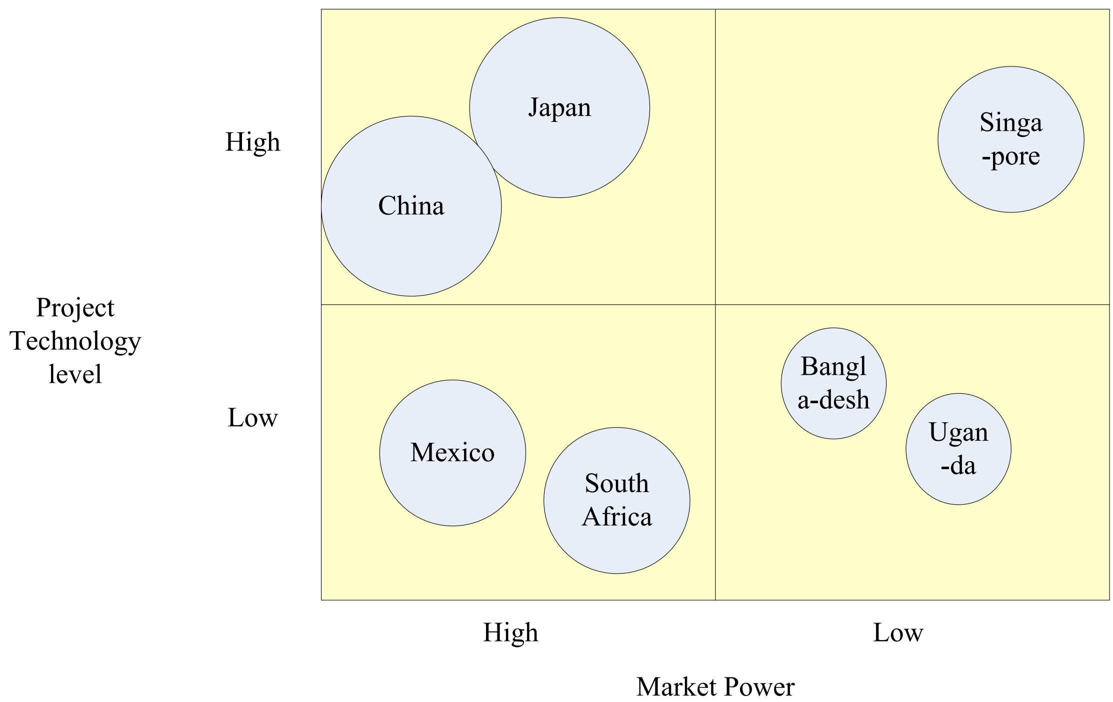
AVIC I and AVIC II effectively cover the entire Chinese aircraft industry, and the split in the 1999 aircraft industry was a major restructuring process. Thus, when the second restructuring exercise was announced in November 2008, there was sense of shock, but not surprise. It is widely recognised that the 1999 split did not work as was intended; there was no competition between AVIC I and II because both companies were essentially producing different products. The planned reintegration of the two companies will lead to six subsidiaries, expected to be based on product lines. A subsidiary specialising in helicopter production has already been confirmed, likely taking over all rotary-wing production within AVIC. Equally, units focused on propulsion will join together to form a Chinese aeroengine company, and China's huge number of aircraft systems manufacturers will come together to create the Chinese equivalent of Honeywell and GE Aviation Systems. Defence units will remain separate from the commercial aviation units, which are likely to be floated on the stock exchange. Significantly, the commercial Aircraft Corporation of China (COMAC) has been created to manage the AVIC's commercial subsidiaries, and is viewed as an industrial organisation that in the future will come to rival Airbus and Boeing.[95]

The re-integrated AVIC will still represent a huge monolithic aerospace organisation, even with six distinct subsidiary enterprises. AVIC's associated establishments will still be in place, and will continue to make an important contribution to the output and welfare of the company. For instance, the aviation industry has two hospitals: one is in Beijing (Central Hospital of Aviation Industry) with 520 staff, including 12 consultants, 91 Vice-consultants and 57 doctors, and the other (China Aviation Industry Xiangfan hospital) is in Hubei, having 220 beds and 30 consultants.[96] The aerospace industry also has six aeronautical universities, including the Beijing University of Aeronautics and Astronautics, Nanjing University of Aeronautics and Astronautics and the Zhengzhou Institute of Aeronautics.[97] In addition, there are numerous specialised higher education technical colleges and school-level institutions specialising in aerospace. Moreover, the Chinese aviation industry has been active in promoting overseas technical cooperation. An important aspect of this comes through a growing export market and also the importation of relevant aerospace technologies. Specifically, for this purpose, the China National Aero-Technology import and Export Corporation (CATIC) was formed in 1979. It provides a two-way street in aviation-related trade. Since CATIC was launched in 1979, it has promoted the export of Chinese-made aircraft and engines, airborne equipment and various other related products to many countries. Also, from the supply-side, CATIC has arranged subcontract work of parts and components at numbers of AVIC factories at Shenzhen, Zhuhai, Guangzhou, Xiamen, Fuzhou, Shanghai, Beijing, Hanzhou, Harbin and Dalian. CATIC also has representative offices in 30 countries and cooperative relations with more than 100 countries.[98]

5.6 21st Century of International Cooperation

International cooperative ventures are viewed by the Chinese planning authorities as technological 'stepping-stones' towards aviation self-sufficiency. There are two issues here. Firstly, all countries seek to partner with advanced countries as a means of gaining technology access. In reality, however, this has not been straight-forward, given the advanced countries' reluctance to release proprietary knowledge. So interpretation of the benefits for a country like China will be influenced by the nature of the project in terms of technological sophistication as well as the bargaining power between the project's prospective partners. If for instance, the project is high technology and the

Figure 5.1: Technology-Market Power Matrix



Source: author

recipient country has low market power, then the potential for substantial technology transfer is low. There is in fact, by reference to Figure 5.1, a mix of possible outcomes dependent upon the strength of the technology-market combinations. In the case of China, the FDI projects it seeks to attract will be high technology and its market power is also, clearly, high. Thus, this conceptualisation of the 'ease' of technology transfer in international cooperative projects suggests that China is in a position to leverage technology transfer. The next section will explore to what extent such transfers have taken place, contributing to the policy goal of aviation self-sufficiency. To begin, the technology development impact of Western OEMs operating in China will be evaluated, followed by local aircraft building initiatives.

5.6.1 Boeing in China

Boeing and the Chinese have enjoyed a long corporate relationship. In 1916, when the US company was founded, a Beijing-born, MIT educated engineer Wong Tsu was hired to design a seaplane, the Model C, for the US Navy. Aside, from China's occasional use of Boeing aircraft since that time, the next major milestone in Boeing's relations with China was in 1972. This was the year when US President, Richard Nixon, visited China before America's long-standing ally, Japan, cementing a new era in China-US relations. Significantly, in the same year, China ordered 10 Boeing 707 passenger aircraft.[99] In the years that followed, China's policy view regarding the strategic importance of aviation was symbolised by, firstly, Vice-Premier Deng Xiaoping's tour of the Seattle Boeing 747 production line during his US State visit in 1979; Secondly, by President Jiang Zemin's visit to the Boeing plant in 1993; and, finally, President Hu Jintao's 2006 visit to the Boeing Everett Factory, when he stated that … "Boeing's cooperation with China is a vivid example of … mutually beneficial cooperation and …[a] .. win-win outcome."[100] Evidence of the strength of Boeing's presence in China can be given by noting that as of 2006, 565 or 61% of the 924 commercial jetliners operating in China were Boeing aircraft (both Boeing and McDonnell Douglas), 251 or 27% were Airbus, and 108 or 12% were from other manufacturers.[101] Moreover, given the expected growth in aircraft demand, Boeing is confident that its dominance will increase. The company estimates that China will require 2,600 new airplanes worth US$213bn by 2024, and of these, single-aisle aircraft such as the Boeing 737 will be the largest category with 1,768 air planes and next will be the 787-777 category with about 568 aircraft.[102] Some orders have already been realized. In 2005, Boeing received 120 firm aircraft orders and a further 40 were received in 2006.[103] On a country basis, these are big numbers; they include a purchase of 60 new 787 'Dreamliner' aircraft, valued at US$7.2bn and 90% of a total order for 150 new generation 737 aircraft.[104]

Boeing's entry strategy into China is not one based on licensed production of complete aircraft, though there is economic justification for pursuing such an approach, given the 500+ Boeing aircraft that China is currently operating.[105] Instead, Boeing's focus has been on placing subcontract work into AVIC factories and developing joint-venture programmes in non-manufacturing activities. Table 5.1 illustrates the broad range of these cooperative ventures. The work is extensive, both in value and the variety of product work undertaken. For example, the value of current supply contracts (737, 777 and 787 signed in 2005 alone was US$600m.[106] The value of total 'active' contracts in place with China's aviation industry in 2005 was valued at US$1.6bn.[107] There are more than 3,900 Boeing aircraft throughout the world with parts and assemblies built in China; this is 30% of Boeing's entire world fleet of approximately 12,000 airplanes.[108] Finally, as was mentioned earlier in this chapter, Boeing has integrated China's AVIC

Table 5.1: Boeing's Industrial Presence in China (1999-2007)

No	AVIC company/products	Aircraft Models					
		737	747	757	767	777	787
1	**Procurement from Chinese-owned factories**						
	BHA Tianjin:						
	composites	√	√	√	√	√	√
	Chengdu:						
	Rudder						√
	Forward entry doors	√					
	Over-wing exit doors	√					
	Empennage (vertical, horizontal, tail sections)			√			
	Hafei (Harbin)						

	Wing to body fairing Panels						√
	Shanghai:						
	Horizontal stabilizers	√					
	Xi'an:						
	Horizontal stabilizers	√					
	trailing edge wing ribs		√				
	floor beams and subassemblies (BCF)		√				
	Vertical fin, forward access door	√					
	Shenyang:						
	Vertical Fin Leading edge						√
	Aft fuselage subassemblies	√					
	Cargo doors			√			
2	**747-400 Boeing Conversion Freighter (BCF) Joint Venture-Xiamen**						
3	**Boeing Joint Venture and enterprises**						
4	**Training, Technical Assistance and support**						
5	**University Cooperative projects**						
6	**Ad Hoc Technology transfer programmes**						

Source: Author, abstracted from various sources.

factories into its Global Supplier Network. China therefore enjoys subcontract relations with some of Boeing's powerful subcontractors, including Fisher, Fokker, General Electric, Goodrich and Hamilton Sundstrand. The types of work packages currently bringing China into Boeing's Global production network of suppliers include the building of large electric wire harness packages (1,000 harnesses per month) for the 737 in Langfang, near Beijing; the building of the General Electric CF34 fan cowling at BHA, Shanghai; other procurements by General Electric for Harbin, Shanghai, Xi'an, Sichuan, Suzhou, Guizhou, and Shenyang; 737 vertical fin and horizontal stabiliser at Shanghai and Xi'an for Korean Aerospace Industries; components for Pratt and Whitney engines at Xi'an, Shenyang and other locations in China by Rolls-Royce.[109]

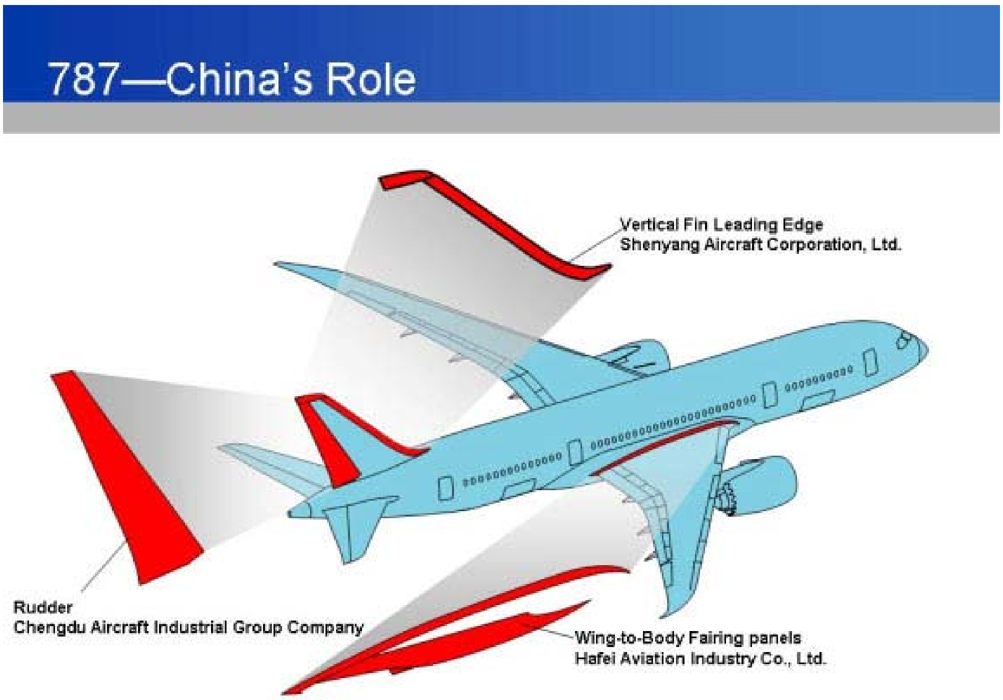
Aside from subcontract work to Chinese aviation companies, Boeing has promoted several other forms of investment over the last 37 years. Table 5.1 gives examples of these additional cooperative activities. They include joint-ventures in aircraft maintenance, modification and repair, maintenance training, flight training and logistical support. An important joint venture, BHA Aero Composites Company, was started in 2002 between Boeing, Hexel and AVIC I. This supplier forms part of a growing Tianjin aerospace cluster. Boeing has a 40% interest in this composites producer, which employs over 500 workers. [110] Training, technical assistance and support are also offered. Often described as ‘soft’ technology transfer, this covers training in flight safety, reliability and efficiency. Boeing has provided high value infrastructure in China to support local development and training, including pilot techniques, flight operation, and air traffic management. These training programmes have been so extensive that Boeing claims 32,000 Chinese aviation professionals have received enhanced professional training from its courses since 1993.[111] Additionally, Boeing has contributed to China’s policy efforts of encouraging local universities to partner in aviation science and technology development programmes. Thus, Boeing collaborates with the Tianjin-based Civil Aviation University of China (CAUC) in the delivery of maintenance training to university students, airline and MRO employees. Boeing has also donated two 737 simulators to the Civil Aviation Flying University of China, Guanghan, along with the associated instructor-pilot training, curricula and mentoring evaluation materials.[112] Finally, Boeing has worked together with China on *ad hoc* technology transfer projects, including joint work on Air Traffic Systems. This has been aimed at a range of technical areas, including safety and capacity improvement to China’s air traffic system and terminal manoeuvring and ground operations at Beijing’s Capital Airport. One further important cooperative venture between Boeing and China’s is the 747-400 Boeing Conversion Freighter (BCF) programme. Boeing has a 9% equality participation in this joint venture project.[113] Started in Xiamen in 1993, it has over 2,600 employees and specialises in the conversion of old 747s into converted freighters. [114] Boeing sells both ‘turnkey’ completed freighter modifications and knocked-down kits of assembled parts to TAECO, the Chinese joint-venture operation that undertakes the build of the parts and subassemblies and does the conversion work. Nevertheless, some of the work is subcontracted out to other Chinese aviation companies. The AVIC factory at Xi’an, for instance, builds the floor beams and some detailed parts and small assemblies for the conversion work.

Figures 5.2 and 5.3 show the contribution of China’s aviation companies to the fabrication of Boeing 737 and 787 aircraft, and whilst Chinese work participation is

Figure 5.2: China's Important Role on the B-737 Aircraft Programme

Source: *Boeing in China*, http://www.boeing.com/companyoffices/aboutus/boechina.html, 17 May 2009.

Figure 5.3: China's important role on new B-787 Dreamliner airplane



Source: *Boeing in China*, http://www.boeing.com/companyoffices/aboutus/boechina.html, 17 May 2009.

growing, the technical sophistication and degree of value-added generated is an open question.

5.6.2 Embraer: 'South-South' Technology Cooperation

The Brazilian aviation company, Embraer, represents a success story. It is one of the world's leading producers of regional passenger aircraft, having delivered more than 7,000 aircraft in the 40 years of its existence.[115] Between mid-1999 and 2007, its ERJ family of regional aircraft had delivered over 1,200 in the 37-50 seat (ERJ 135,140 and 145 range) and 70-108 seat (ERJ 170, 175,190 and 195 range), with 1,750 firm orders.[116] Embraer believes that the global demand for regional jets will grow dramatically in the future. For the period 2008-27, it is projecting deliveries worldwide of 7,450 jets, with North America accounting for 45% of this total and China representing the third major market, with 10%.[117] This represents 730 aircraft, of which 450 will fall into the 91-120 seat range and 170 in the 30-60 seat range.[118] Such growth forecasts were a key factor in persuading Embraer to compete for entry into China at the beginning of this century, offering licensed production of its aircraft.[119]

In year 2000, Embraer opened its representative office in Beijing to act as the organisation's HQ in China, as a point of contact in liaison with Chinese aviation government officials, and as a China sales office. Sales of Embraer aircraft were modest in the early 2000s, mostly 'light' commercial jets, but the company believed that market for regional aircraft was set to grow rapidly. This was based on the fact that at that time, Chinese airlines only had 73 regional aircraft, 7.1% of the country's total fleet of aircraft, compared to a 35% ratio for the US and Europe.[120] Accordingly, Embraer entered into China as a long-term 'strategic' partner, forming a joint-venture with AVIC II in December 2002. The joint venture was located at the AVIC II Harbin aviation factory complex and was thus called the Harbin Embraer Aircraft Industry. The ownership is split: Embraer 51% and local partner HAFEI 49%; the first time a foreign aviation company operating in China has been allowed to have controlling market share.[121] The total investment commitment was US$40m, with an emphasis on quality control and equivalent production standards as in Brazil, and a commitment to transfer technology.[122] Currently employing 250 workers, the joint-venture by 2005 had delivered 14 aircraft to various Chinese Airlines,[123] and enjoys a full order book until 2010, with deliveries in 2008 reaching 200 regional jets.[124] The big breakthrough for Embraer came in August 2006 when it won its first contract for ERJ jets on mainland China. This was the sale of 50 ERJ 145 and 50 ERJ 190 aircraft, worth US$2.7bn.[125] Following this success, Embraer invested in a spare parts warehouse in Beijing and a Fight Training Centre in Zhuhai.

5.6.3 Airbus China: The European Breakthrough

The December 2005 signing of the Memorandum of Understanding between visiting Chinese Premier Wen Jiabo, and EADS Airbus, at its headquarters in Toulouse, France, signalled Europe's breakthrough into the Chinese aviation market via licensed production of the successful Airbus A320 passenger aircraft. This was not a sudden development, however; Airbus China had opened its representative office in Beijing as long back as 1990, and now employs 260 staff, four out five being Chinese nationals.[126] Over the years, Airbus' presence in China's aircraft market has grown. In 2008, there were 260 Airbus aircraft in service with Chinese carriers.[127] The European company's first sale in China was to the Shanghai-based CAAC (now China Eastern Airlines) in 1985; it is now Airbus' biggest China customer, with a fleet of 93 aircraft.[128] As with Boeing, Airbus grew its business in China over the years by agreeing 'offset' subcontracts with AVIC companies. From Table 5.2, it can be observed that the Shenyang and Xi'an aircraft factories produced various components and subassemblies for both the A320 and A330/340 Airbus families of aircraft. Thus, around 50% of the Airbus fleet in service worldwide has parts produced by Chinese companies.[129]

The creation of the Airbus China factory at Tianjin's Binhei New Coastal district is to build the Airbus A320 aircraft. In essence, this licensed production of the A320 is an offset project tied to China's October 2006 procurement of 150 of these aircraft; the transfer of assembly capacity being a condition of Airbus winning this massive order.[130] The Tianjin complex will comprise production areas, hangars, offices and related facilities. The 'shop-floor' will be technological 'state-of-the-art', similar in all respects to the Airbus single-aisle finally assembly line in Hamburg, Germany. The Airbus

Table 5.2: Airbus's Industrial Presence in China (1999-2007)

No	*AVIC company/products*	*Aircraft Models*	
		A320	**A330/A340**
1	**Procurement from Chinese-owned factories**		
	Tian Jin:		
	Final assembly line	√	
	Cheng Du:		
	Rear passenger door	√	
	Nose section	√	
	Shen Yang:		
	Emergency exit door	√	
	Fixed leading edges	√	
	Wing interspar ribs	√	
	Skin plates	√	
	Cargo doors		√
	Xi'an:		
	Electronic bay doors	√	√
	Fixed trailing edges on wings	√	
	Medium air ducts		√
	Brake blades		√
	Shanghai:		
	Cargo doors frame	√	
	Hong Yuan Forging & Casting (HYFC)		
	Titanium forging parts to mount powerplants on to wings		
	Hafei (Harbin)		
	Horizontal stabilizers ribs	√	
	Horizontal stabilizers	√	
	Guizhou		
	Maintenance jigs and tools		
	Airbus Joint Venture and enterprises		
	Tian Jin: joint venture between Airbus and a		

	Chinese consortium of Tianjin Free Trade Zone (TJFTZ) and China Aviation Industry Corporation (AVIC).		
2	Airbus (Beijing) Engineering Centre (ABEC): joint venture between Airbus and AVICI, AVICII		
	Training, Technical Assistance and support		
	Airbus Beijing training centre		
3	Airbus customer support centre		
	University Cooperative projects		
	Technology transfer programmes		
4	Complete wing manufacture of the A320		
5	**Industrial partnerships**		
	Roll-on, roll-off ship that transports A320 components was built at the Jinling shipyard		

Source: Author, abstracted from various sources.

China plant commenced operations in 2008, with the plan to deliver the first A320 sometime in late 2009. By 2011, it is expected that the production line will be producing four A320 aircraft each month.[131]

Airbus has committed to developing new industrial partnerships in China based around its Tianjin assembly complex. For example, given that the Tianjin Airbus assembly line is the first to be located outside Europe, the logistical challenge of shipping major aircraft sections from Toulouse to China is profound. Thus, a Chinese team of engineers was involved in the design of a specially commissioned 'roll-on, roll-off' ship that transports Airbus components/subassemblies from Europe to China; the ship itself was constructed at China's Jinling dockyard.[132]

5.6.4 'Flying Phoenix (*Xiong Feng*): China's Aviation Industry Comes-of-Age?

China's burning ambition to develop its own passenger aircraft led to the dramatic launch of its first 'indigenous' aircraft, the 90-seat ARJ 21-700,(Advanced Regional Jet for the 21st century).[133] It made its maiden flight in November 2008, landing safely at Shanghai's Baoshan airport after an hour's flight. The aircraft has been designed and produced by the commercial aircraft corporation of China (COMAC), part of AVIC's industrial empire. It is produced under COMAC management at AVIC's Shanghai factory and the plan is to obtain the airworthiness certificate in late 2009. China has presently secured 208 orders for the jet including five firm orders from General Electric's aircraft leasing arm.[134] Production capacity for ARJ 21 is currently 20 per month, but by 2011, will ramp-up to 30 per month.[135] The first five aircraft will be used for the flight test programme, and another two for ground-based stress and fatigue trials.[136]

Western OEM interest in participating in the ARJ 21 programme is driven by the fact that it is a Chinese-government backed project, placing it at a competitive advantage over local and foreign rivals, Embraer and Canada's Bombardier, respectively, in the regional aircraft market. It is also competitively priced, selling at around US$27m, compared to US$30m for the 90-seat Bombardier jet.[137] COMAC argues that its 3,000 km range will mean that the ARJ21 jet will take 60% of China's 900 mid-sized aircraft market over the next 20 years, not least because it will have … "less fuel consumption and longer flight hours … than the current large aircraft above 140 seats on short and medium routes."[138]

China's development and production of the ARJ 21-700 aircraft is a key milestone in the development of China's indigenous aerospace industry. Combined with the investment by Boeing, Embraer and Airbus, it is clear that a critical mass of aviation capacity and capability in China is being developed. It is also a dynamic environment with Airbus planning to building around 5% of its next-generation A350 aircraft in China's factories,[139] with Boeing sourcing sizeable chunks of work from China on its next-generation 787 aircraft, and Embraer considering expanding its Harbin production range to include the bigger ERJ-190.[140] Moreover, China's emphasis on competitiveness, rather than technology transfer alone, is arguably right.[141] The ARJ 21 is positioned precisely in the market segment that local producer Embraer is targeting with the ERJ-145 aircraft, and this is clearly deliberate on the part of China's planning authorities, seeking the benefits of cost-reduction.[142] Part of this search for production efficiencies, however, involves China's recognition that 21st century aircraft production does not equate to self-sufficiency for any of the manufacturing countries, save possible for Russia. In a globalised economy, aircraft production, by definition, means engagement into global production networks to exploit the advantages of international specialisation. Thus, China's 'indigenous' ARJ 21 has a multitude of Western subcontractors accounting for a high proportion of this aircraft's value-added.[143] Here subcontractors include: GE (aircraft engines). UTC Hamilton Sundstrand (power generation); Rockwell Collins (Avionics); Parker Aerospace (fuel systems and hydraulic products); Honeywell-Parker Hannifin (primary flight control systems); Liebher Aerospace (landing gear); ACSS (communications and surveillance); Eaton Group (integrated cockpit assemblies); and FACC AG (aircraft cabin interior design and production).[144]

The final point to emphasise is that the ARJ 21 does not represent the end-game in China's aviation industry's ambitious plans. It still seeks to move from 'basic fabrication to global competitor, vying with Europe's Airbus and America's Boeing as the World's third major developer and producer of large passenger aircraft. The May 2008 creation of COMAC is a tangible expression of that dream. Not only did COMAC inherit the ARJ 21 production apparatus, but it was also charged with the future build of a 150-seat aircraft that would compete with Boeing and Airbus by 2020.[145] As with the ARJ 21 programme, foreign OEMs, will likely seek to engage these further development plans…as one Rockwell executive put it. … "we understand that … [China] … may well want to develop an indigenous industry, but we want to stay part of it as long as we can."[146] To complement the development of China's future large aircraft airframe, it was announced in November 2008 that China would invest US$883mn (RMB6bn) to indigenously develop the aircraft's engines. AVIC is to partner with the Shanghai government to develop China's First high-tech, commercial aircraft engine.[147] AVIC's Executive Vice-President is quoted as stating that … "the initiative is costly and risky, but it is worth attempting because the aeroengine industry would stimulate supporting industries."[148] Although restrictions on foreign holdings may be imposed, as Beijing sees the aeroengine industry as 'strategic', the venture will likely involve international participation with strategic partners, such as GE and RR.[149] With or without equity partnership, the big aircraft aeroengine project will procure parts and design through international tendering.[150]

5.7 Progress Towards Indigenous Industrialisation

The road to indigenous aerospace capacity in China has proved long and difficult. During the Second World War, the Chinese gained some basic aeronautical experience, repairing US warplanes.[151] Then, after 1949, there was the close relationship with fellow Communist state, the USSR, leading to the licensed production of Soviet aircraft. In 1958, Beijing stated, unrealistically, that it would surpass Britain's economy in 15 years, but then came the 'big leap', the departure of Soviet advisors, and the uncertainty of the Cultural Revolution, when the technology gaps between China and rest of the World increased and China's aviation industry was paralysed.[152]

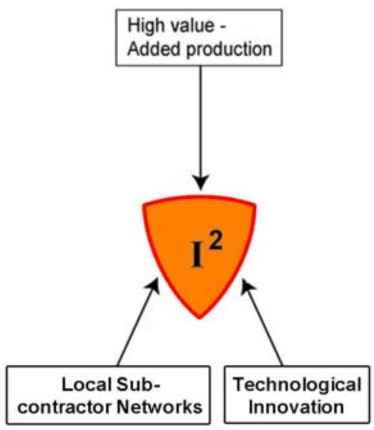
Table 5.3: Summary of China's Aviation Company Survey, 2008

Profile	Embraer	Airbus	AVIC (ARJ 21)	Rolls Royce	Safran
Year of Commencement	2000	2009	2008	1997	1989
Product Range	Commercial Jets, Executive Jets Defence Jets	A320 assembly production	full range, including civil and military	aviation, marine and energy	Aerospace Propulsion Aircraft Equipment Defence Security
Employment 2008	270	N/A	400,000	350	3290
Sales 2008	US500m to 550m	N/A	RMB150 billion	N/A	N/A

Source: author

The new dawn began in 1978 with the introduction of the 'open-door' policy. Looking back, it is difficult to identify the existence of any coordinated and progressive government strategy.[153] yet notwithstanding the lack of a coherent strategy, it is possible to identify three distinct development periods: from 1980 to 1990, foreign aviation companies were invited to relocate, but this new-found 'capitalist' liberalisation era focused on solving short-term problems, creating employment and profit rather than pursuit of the long-term goal of indigenisation; the second phase during the 1990s, was much more focused towards learning management and manufacturing skills through increased international cooperation. The pace of technological learning picked up in the latter part of this decade, through the local production of components for Boeing aircraft; finally, in the post-2000 period, China promoted the joint-venture concept, welcoming foreign companies through whole-aircraft licensed production, covering such aviation programmes as Embraer-Harbin, Airbus-Tianjin, and extending to including helicopters and aero engine production. China is now entering a fourth and possible final stage, where the focus is on 'Chinese made' aircraft.[154] AVIC's position is clear in this regard, that to progress towards increased indigenisation, international cooperation is essential. However, the search for cooperative harmony [155] is not easy. It is reported that GE sought a 'signing-on' (or entry) fee for a particular cooperative programming, amounting to US$100m.[156] Presently, all three phases (corresponding to the three stages outlined in 5.3.3) coexist. Subcontract work, often secured through offsets, helps China develop and enhance skills, creates local jobs and raises capacity-utilisation, production quality and shopfloor management. International equity investment, as at BCF (Taikoo Aircraft Engineering Co.), Xi'an, and BHA Aero composites Co, Tianjin, is now an established model that injects risk-sharing capital

Figure 5.4: Metrics to Evaluate Progress towards Developing an Indigenous Chinese Aviation Industry



into China-based manufacturing operations. License-production by Embraer and Airbus of complete aircraft, increases the level and sophistication of risk-sharing and also the 'potential' for technology transfer, leading to indigenous development. The question is whether these different forms of technology transfer have raised indigenous capability; that is, whether value added, technological innovation and supply chain capabilities (see Figure 5.4) have actually been raised.

5.7.1 High Value Added Production

Value added in China's commercial aviation factories remains at a low level. This represents an informed judgement, because the interviewees found this to be a question that they were unable to respond, even with approximate values. What is known is that China has always viewed international cooperation as a means of achieving effective access to technology. The first major cooperative project with the West did involve transfer of technology, albeit that the MD-82 was itself 'old' technology.[157] All documents and blueprints were transferred to the Chinese partners, but local production only involved the airframe.[158] The follow-on international cooperation project was with Airbus on the Asian Express 100, but this project failed because Airbus would not agree to, firstly, technology transfer, particularly, wing technology, and, secondly final assembly in China. In the end, Airbus preferred to develop an alternative aircraft, the A319 on its own.[159] The senior Embraer representative indicated that 97% of aircraft production work at Harbin was done by local people,[160] but later in the interview she stated Harbin's focus was on assembly and testing.[161] The major high value systems continue to be imported from foreign-based OEM suppliers; that is, Embraer's programme in China is concerned with licensed production of existing aircraft, not the development of new aircraft.[162] It is a similar story for the licensed production of the Airbus A320 at Tianjin. This is an assembly project, and there is thus only minimal transfer of technology,[163] and this is a major reason for AVIC's small (9.8%) equity share. Finally, although China is a supplier of parts to Boeing on its B787 aircraft (see Figure 5.3), its share of the global programme's structures (and, correspondingly, value added) is less than 4%, whilst Japan takes 35%, equal to that of Boeing.[164]

The lack of serious technology transfer to China is reflected by the role of the sub systems manufacturers. Rolls-Royce, for instance, has been in China for close to 50 years, since China purchased British Viscount Turbo-prop commercial aircraft, using Rolls-Royce aero engines. Subsequently, in the 1960-1970s, China purchased Trident aircraft, also using Rolls-Royce engines, but this was an aircraft that proved to be uncompetitive against the B727, allowing American Aircraft and aeroengine manufacturers to increase market share in China.[165] In 1983, RR sold China 50 new Spey engines for military purposes (integration into the PLA Navy's 'Flying Leopard' Attack Fighter). Also sold were a number of reconditioned ex-RAF engines, and later, RB211 engines for China's growing commercial fleet of aircraft.[166] Since 1989, because of the embargo on military sales, Rolls-Royce has focused on growing its civil activities in commercial aviation (for instance, it is a supplier to most of China's airlines; indeed on the A330 programme, it received an order for 100 engines, where it has captured a 100% market share).[167] Rolls-Royce also has important markets in marine propulsion, offshore oil/gas exploration, energy power generation and even the supply of compressors for the Sino-Russian 'West-East' Gas pipeline.[168] However, throughout Rolls-Royce's long and close business relationship in China, technology transfer has never been conceded by the British company. A Rolls-Royce executive argues that it will not transfer technology, as it must safeguard the interests of its shareholder.[169] A further point is made that to enjoy a sustainable business model in the West, low cost structures and the promotion of training in the development and production of commercial aeroengines are essential conditions. However, as yet, these considerations are not ingrained in the Chinese business culture, and so business risk for foreign collaborators increases to unacceptable levels.[170] Even today, it seems China's traditional centralised industrial culture remains: status and hierarchy being more important than a focus on product-to-market efficiency.[171]

Minimal technology transfer into China's aviation industry means low value added in an industry where there is limited local absorptive technology capacity. For instance, in the field of technology offsets, China introduced an offsets policy in 1993, specifying an institutionally required target of 30% (conservative by present day standards, where 100% is standard), but because of low levels of local technological capability, not even that low percentage figure could be reached, being drawn down to 4-6% by the late 1990s.[172] The problem of low value-added production in local programmes also extends to China's 'indigenous' ARJ 21 project. It is argued that this Chinese aircraft will have only 15-20% of local value-added, with 80% of the high value propulsion, electronics and avionics work coming from foreign companies that are supplying 19 major aerospace sub-systems.[173]

The full picture of value added for the principal aircraft programmes in China is given in Table 5.4 below. It is clear from this table that value added in China's aviation industry is low. With China's aircraft building programmes importing almost all the high technology sub-systems, local labour is simply engaged in fabrication activities.

Table 5.4: Local Value Added in China's Aviation Industry, 2008

Local Value added (%)	Embraer	Airbus	ARJ 21	Boeing	Rolls-Royce	Safran
>20						
≤20 and ≥10			√			
<10	√	√		√	√	√

Source: China Fieldwork (October 2008)

The local value-added content of Chinese produced aircraft will rise in the future, however, as the technology and learning is 'infused and diffused' across the aviation sector, from both local and foreign endeavours. For instance, Airbus has several major technology transfer programmes underway, including, the transfer of wing technology, focused in the first instance on the complete wing of the A320 family to be manufactured in China.[174]

5.7.2 Technology Innovation

None of the companies interviewed admitted to having registered patents: indeed, for the sub-systems manufacturers it would have been surprising to find that patents had been registered. This is not their purpose for being in China, rather it is to develop markets, sell aircraft or systems, so adding to corporate profitability. The same applies to R&D expenditure; Embraer and Airbus programmes focusing on assembly of components and aircraft structures produced elsewhere. China's aviation industry, as yet, is too immature to engage in innovation prior to gaining industrial expertise in manufacturing these systems. Roll-Royce provides an example of how foreign aviation companies' focus is on business development in China, rather than on technological partnership. Rolls-Royce has never had any production in China, nor assembly, nor testing work.[175] There are no logistical advantages for sitting such work in China. Moreover, the Chinese government imposes no local content requirement on foreign investment, and currently, there no offset conditions.[176] Notwithstanding Rolls-Royce historical trading focus in China, its position is beginning to change as this global company starts to 'localise'. For instance, until 2003, all service representatives' frontline engineers at the interface with customers were expatriates, but now all 38 service representatives are Chinese nationals.[177]

Innovation is held to occur through problem-solving, via industrial flexibility, the interchange of ideas, clear communications and as a deep understanding of the technology processes and requirements. However, it is well-known that the Chinese innovation system is struggling to overcome the centralised inflexibilities and inefficiencies of the Communist Central Planning regime inherited by AVIC and faced by foreign companies operating in China. Although AVIC controls research institutes and several specialised aviation universities, there is no evidence that focused innovation is emerging. China's successful space effort, however, proves that innovation can result from institutional specialisation and generous government financial sponsorship. This appears to finally be about to happen in aviation, promoted by both national pride, as in the space programme, and also the commercial benefits from the country's massively expanding demand for commercial aircraft. However, as shown in Table 5.5, 'corporate' R&D expenditure in China's aviation industry is negligible.

Table 5.5: R&D Expenditure in China's Aviation Industry, 2008

R&D Budget	Embraer	Airbus	AVIC ARJ 21	Boeing	Rolls-Royce	Safran
Some			√			
No	√	√		√	√	√

Source: China Fieldwork (October 2008)

China's institutional and corporate culture is likely to change with the country's new competitive realities. The China aviation survey found no obvious cultural problems associated with the industry's numerous foreign partnerships. There was mention of slowness in decision-making due to hierarchical structures;[178] the lack of commercial priorities leading to relatively higher cost structures, and here it is instructive to note the higher costs of producing the Tianjin A320 compared to the equivalent aircraft produced in either France or Germany.[179] Although not a major problem holding back the advancement of China's aviation industry, there was evidence of some misunderstanding and poor communications between local and foreign management teams resulting in inefficiencies. In one instance, this had occurred in the implementation of the 'Six Sigma', management system, where there had been misinterpretation regarding management requirements between the Chinese and overseas partners.[180]

Technology can be both 'hard' and 'soft'. On the soft side, an important element is knowledge and learning. Here, much more is being done by foreign aircraft companies in China to promote the transfer of knowledge. As can be seen from Table 5.6, most of the major aviation programmes have incompany training schools. This is unsurprising, given that in those programmes, focused on manufacturing, but also applying to even services, a premium is based on quality and safety. For example, the Airbus Aviation

Table 5.6: Incompany Training School in China's Aviation Industry, 2008

Incompany training Schools	Embraer	Airbus	AVIC ARJ 21	Boeing	Rolls-Royce	Safran
Yes	√	√	√	√		√
No					√	

Source: China Fieldwork (October 2008)

Training facility at Beijing airport is particularly impressive. It was established jointly with the China Aviation Supplies Import and Export Corporation in 1998, and is claimed to be the most modern such facility in China, with two full simulators: one for the A320 family and one for the A330/340 family.[181] The centre has trained thousands of maintenance engineers, cabin crew and pilots.[182] Moreover, AVIC has signed an agreement with Cranfield University to train 150 of the company's engineers in aircraft and jet engine design, with the aim of creating a 130-seat indigenous aircraft.[183]

5.7.3 Aviation Supply Chains

The possession of local subcontractor value chains is what distinguishes advanced industrialised countries from those that are industrialising. Small, specialist supplier firms are where the pool of labour skills is located, generating technological innovation through networking between customers in the supply chain and also through relationships developed locally with similar companies and also specialist research institutes and local universities within the industrial cluster.

A major challenge China faces in the short to medium-term, is not so much manufacturing aircraft, but learning supply chain management; that is, the need to both provide ongoing support services for a global fleet of commercial aircraft and also the requirement to develop the specialist manufacturers that will support the ARJ-21 and similar projects in the pipeline, in the evolving large indigenous aircraft and engine programmes. For an industrialising country, such as China, that has not had the benefit of generations of industrial development, the conventional approach is to cultivate the creation of industrial clusters as a way of 'leap-fogging' over the very long-term time period required to evolve a subcontractor base. Accordingly, China has been active in applying policies to promote such clusters in its growing civil aviation area. Chengdu, for instance, has long been the focus for the production of military aircraft. However, in recent years, it has been working hard to diversify into commercial production. In March 2008, for instance, AVIC I cooperated with the Chengdu Municipal Government to create what is claimed to be China's first aerospace high-tech industrial base.[184] The plan is to develop Chengdu's high-tech zone into a cluster of aerospace-related supporting industries. A telecommunications university (University of Electronic Science and Technology of China) is located there and also an integrated circuit supply chain, including 50 design companies; indeed, there are more than 11,800 companies registered in this cluster, among which 674 companies are foreign enterprises, including 33 Fortune 500 companies, including Intel, IBM, Symantec, Microsoft Fujitsu, NEC, Motorola, and Nokia.[185]

Harbin, the home of the Embraer aircraft production facility, has also been developing its own cluster. Embraer's investment in Harbin has been totally through its own risk capital; there being no Chinese government support.[186] It has entered into the joint-venture with AVIC on the basis of long-term mutual benefit.[187] Thus, it intends to gradually build-up a local supply chain. Currently parts of the fuselage and some of the composite fairings have been outsourced to local suppliers.[188] This represents modest beginnings, but it is a start. In Tianjin, the central/local government is equally keen to promote a local aerospace cluster. Airbus is reportedly investing between RMB8-10bn in this project, embedding more than 200 Airbus technicians in the Tianjin factory to direct the assembly process.[189] Airbus also intends to engage in a long-term strategic partnership with China that will contribute to the promotion of local value-added, skills and value chains.[190] In this regard, six Chinese manufacturers are already involved in manufacturing parts, such as wing components, emergency exit doors and assembly and transportation tools for other Airbus aircraft. It is reported that in 2007 alone, Airbus sourced US$70m worth of components and materials from Chinese companies; this will treble to US$200mn by 2010, and will double again to US$450mn in 2015.[191]

In the case of Boeing, whilst it has no 'whole-aircraft' production facilities in China, it has nevertheless contributed substantial numbers of offset contracts to Chinese aviation factories, including Chengdu for 787 work and Shanghai and Xi'an for 737 fabrication packages. Xi'an also acts as a major supplier to Boeing in its 747 conversion factory at Xiamen. Other long-standing suppliers include Southwest Aluminium, Chongqing, a supplier of Aluminium Forgings on 747s since 1988, and Hongyuan, Sanyuan, a supplier of titanium forgings for 747s since 1984.[192] In terms of foreign sub-systems suppliers, such as Rolls-Royce and Safran, both companies are now beginning actively to contribute to the development of local subcontractors. Rolls-Royce, from a position where it had no suppliers a few years ago, now has five local suppliers.[193] All are state-owned Chinese groups, including Xi'an-based suppliers producing turbine glide blades and assembly of aeroengine blades.[194] Rolls-Royce, like Airbus, is committed to developing a local value base. This can be evidenced by the trend of increase in Rolls-Royce's China procurement budget: US$20m in 2003, US$200m in 200, rising to US$500 m by 2011, including plans to develop a local non-destructive testing factory.[195] The French company, Safran, is also engaged in a rapid expansion programme in China. The approach that it is taking is to create specialist subcontractors through joint ventures with local aerospace companies, primarily, to date, AVIC. By April 2008, three joint venture factories had been opened in China, specialising in, for instance, systems controls for aeroengines.[196] A further six factories are planned that will specialise in engine parts, the forging of aeroengine blades, and MRO services.[197] Safran's Chinese employees now more than 3,290 and the company sponsors eight Chinese students every year to train in France via aeronautical internships.[198] Safran also collaborates with the Beijing University of Aeronautics and Astronautics and the Xi'an North West Polytechnic on major high technology research projects.[199] Table 5.7 shows that all China's aviation companies are seeking to promote local supply chains.

Table 5.7: Prime Contractor Support for Local Subcontractors, 2008

Involvement with local subcontractors	Embraer	Airbus	AVIC ARJ 21	Boeing	Rolls-Royce	Safran
Yes	√	√	√	√	√	√
No						

Source: China Fieldwork (October 2008)

China's government is committed to the development of an indigenous aviation industry. AVIC, in particular, recognises that this strategic or 'backbone' industry must take the responsibility for driving the development of a local supply base, as a means of overcoming the present capability weaknesses in raw materials, electronic components, metal products and processing supply.[200] There is also a recognition that this will be expensive, because access to foreign high technology is restricted by the reluctance of foreign OEMs to transfer; added to which are the controls placed by foreign governments on the transfer to China of sensitive technologies, such as critical engine and composite technologies, electrical systems and sophisticated micro electronic chips.[201]

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Chapter 6 Conclusions

6.1 Summary

The purpose of this research project has, firstly, been to evaluate the development of Asia's aviation industry, and, secondly, at a more focused case study level, to analyse China's progress towards the policy-goal of developing an indigenous aviation capacity. Although these research questions are clear, there are a number of contextual factors which act as important conditioning variables on the outcome of this analysis. Firstly, the aviation industry is generally regarded by economic planners in developed and developing countries, alike, as a 'strategic' industry. There are several reasons for this policy emphasis, the more important of which include:

- **Economic**: the aviation industry employs relatively high numbers of workers (in the case of China, there are over 500,000 workers in AVIC, alone). The industry also has the potential to stimulate employment in supplier industries, from metals, wiring and plastics to electronics, avionics and services. Moreover, from the standpoint of micro-and macro-levels of economic activity, the industry's income and investment expenditure will contribute powerful economic multiplier effects to regional economic growth.

- **Technology**: there is no doubt that the aviation industry is more than simply a growth pole within the economy; it also operates at the technological frontier, pushing the boundaries of innovation to new levels. Technological developments may impact on materials, such as composites, so as to reduce aircraft weight and thus operational cost, and on electronic technologies, whereby the introduction of computerised flight systems carries the benefits of reduced cost and, more importantly, increased safety. From interviews, the issue of safety has been highlighted as a major consideration in the design, development and production of aircraft components and systems for the commercial, far more than the military, customer. This emphasis on product improvement represents a key sub-theme of the aviation industry's technological development, influenced by the extent and depth of local research and development capacity. This may be expressed in different ways:

firstly, through formal corporate and government-sponsored R&D activities; secondly, through innovational developments by the high tech. subcontractors in the supply chain; and, thirdly, through the embedded skills of the engineering staff within the industry. The successful global aviation players, such as Boeing, Airbus and Embraer, will likely enjoy high levels of expertise at all three levels. By contrast, the emerging countries' aviation industries, such as those in Malaysia, Singapore and Indonesia, will suffer deficiencies, particularly in regard to corporate and institutional R&D as well as from limitations from the 'gaps' in local supplier-customer interactions.

- **Political:** there is an important political dimension to the creation of a local strategic industry such as aviation. The development of an international 'branded' good derived from domestic industry carries with it national prestige and broader regional and even global respect. Most countries have the aspirations, but few have the necessary resources, scale and long-term commitment to acquire quality engineering required for entry into large aircraft production; the latter, thus symbolizing a major achievement in the acquisition of technological capability.

- **Military:** an important associated characteristic of developing commercial aircraft production capacity are the likely benefits to be obtained from technological spin-offs and civil-military integration. For most industrialising countries, including China, the early years of economic development would have focused on two objectives: the transition from agricultural to industrial activities within the economy and the creation of a defence capability to defend independence. The production of commercial aircraft is normally not considered during the early phases of industrialisation, but military aircraft is a different matter. The depth of capability will be dependent on the extent of industrialisation achieved, but the initial creation of aircraft building capacity will be limited to the availability of local resources, including capital and appropriate engineering skills. Inevitably, the lack of access to technology will be a major limiting factor to local aircraft production. Thus, the import of combat aircraft will be a necessary first step, and then over time, the growing value of aircraft purchases can be used to leverage technology transfer. In the beginning, such transfers will be rudimentary, moving from basic MRO provision, to progressive transfer of manufacturing capability. Military production capacity is prioritized because of the need to protect the host country's nationhood, sovereignty, and independence. Sovereignty is fundamentally important for poor, ex-colonised states, and even in the present era of globalisation, it remains a key driver of industrial and technological planning. Sovereignty requires interpretation, however. Not even Boeing and Airbus are self-sufficient in the design and development of large aircraft, with much of the work outsourced to systems and sub-systems suppliers. For instance, as stated in the main body of the text, around 40% of the components and structures in the Boeing 787 Dreamliner is sourced from overseas companies. Yet, whilst Boeing is global, having manufacturing networks spread across many countries, it is still viewed as a US company. Significantly, many of the world's aerospace companies produce both civil and military aircraft platforms and systems. Thus, as the industry develops and matures, there is the potential for technology spin-off to occur, so that military-related aerospace innovation can be transferred to the commercial aircraft division of the same company. For instance, EADS, the parent body of Airbus, builds Airbus commercial aircraft, such as the A380, as well as the A400M heavy-lift military transporter aircraft; Boeing produces the B747 'Jumbo' aircraft as well as the F-35 Lightning fighter aircraft; the Indonesian aircraft company, PT Dirgantara, builds both commercial and military versions of the CN235 aircraft; and the Chinese aviation company, AVIC, builds military aircraft, such as the SU-27 and J-10 'indigenous' fighter as well as the ARJ-21 commercial aircraft. Perhaps the real policy issue is not whether major innovations have been transferred from the military part of the business to the civil, and *vice* versa, but rather whether accumulated technology resources are sufficiently 'cross-threaded' to ensure that civil-military synergies can be enjoyed by the company. Civil-military integration can thus be viewed as exploiting the dual-use nature of skilled labour, technical capacity, test equipment, MRO as well as key enterprises in the emerging value chain.

For all of the above reasons, as China has 'opened-up' and developed its industrial base, it has partially defined sovereignty (indigenisation) in terms of sustainability, and to achieve this goal in an increasingly commercial environment, there is a need for competitiveness. This is an enlightened business model, reflecting the need to reduce the high opportunity costs of inefficient local production when benchmarked against imports from off-the-shelf procurement. Therefore, up to the present time, China's apparent policy-goal has been to promote local aircraft production capability through licensed production, such as with Airbus, Embraer, Rolls-Royce and Safran, and the technology transfer sought has not so much been on the 'hard' side but rather the 'soft' side; that is, training, management techniques, logistical organisation and supply chain modalities. This may be beginning to change, though, as signified by China's recent policy emphasis on developing an 'indigenous' aircraft, the ARJ-21, and also the vision of developing a large aircraft and related large engine. The rationale for promoting an aviation industry, as a strategic industry, is therefore multi- dimensional in character. In the 21st century context, however, scale (volume) and to some extent scope (diversity) is critical. Size matters, but so does specialisation, and that accounts for Embraer's survival, given the limited size of Brazil's domestic market. An external export focus is thus an important consideration. It is simply not sufficient that Boeing is located in the world's biggest economy and Airbus is located in the equally big European market, because whilst the domestic base for aircraft should be substantial, the local market does not provide the level of demand required for critical mass to be achieved. The world to this point can only sustain a global 'duopoly' of aircraft producers. However, China's huge projected domestic demand for commercial aircraft linked to the country's explosive growth in air transport demand may provide the economic justification for China's entry into the global high tech. aerospace market.

A poor country cannot simply build commercial aircraft; it needs to put in place a manufacturing infrastructure, and, importantly, the appropriate skill base. So a poor country obviously prioritizes design and implementation of policies to promote basic development, driven by the need for economic transition from agricultural dependence (on cash crops) to industrialisation. To facilitate such a transformation, the poorer countries will need access to technology. This very quickly becomes a serious challenge to policy-makers, because by definition poor countries do not have access to technology, or at least their own technology. Under such conditions, countries must choose one of the following options:

i) Incountry Technology Development:

This will tend to come through local R&D and the creation of domestic capacity and skill enhancement programmes. This, however, is an expensive option and unlikely to succeed quickly because of the absence of manufacturing infrastructural foundations. There really is no precedent for poor countries embarking on industrialisation to position local industries in the high technology field.

ii) International Technology Alliances:

This is a method some countries use for acquiring technology, and at the same time sharing the acquisition cost, but here as before with option i), above, it is expensive and not an appropriate strategy for an emerging nation. The approach requires that country-partners make an acceptable contribution to the collaborative effort, either through capital funding or industrial capability. However, poor countries will likely have nothing to contribute. So whilst Japan is partnering with Boeing on the development and production of the B787 Dreamliner aircraft, and with Roll-Royce, Pratt and Whitney, GE, and MTU on the V2500 turbo-fan engine, it is doing so from a position of industrial and technological maturity. This technology advantage will not apply to the majority of other countries in the Asia-Pacific region.

iii) Technology Transfer via FDI/Offsets:

Most developing countries seek not to ‘reinvent the wheel’ in their policies to promote technology development. FDI is a logical way forward, therefore. By contrast to the 1970s, when MNCs were viewed as exploiting labour in the so called Third World countries, this view has now been completely reversed in today’s era of globalization. All countries now see FDI as a positive force, with MNCs creating production capacity, jobs, skills, exports, backward linkages, and, through technology transfer, the prospect of self-reliant industrial capability. Whilst MNCs can bring such benefits to the overseas host economy, the net advantages are not always so clear-cut. Taking a 'realist' perspective, it is obvious that the big foreign aviation OEMs will release technology reluctantly, rightly fearing loss of competitive advantage. So if foreign firms do transfer technology, it will be 'old' technology as in Vernon's theoretical IPLC model and as also in the applied example of MD-82 aircraft production in China.

The developing countries see 'offsets' as a possible way around the technology transfer '*impasse*'. Offsetting investment can be sourced either through military or civil contracts, and is viewed by most industrializing countries as a 'win-win' vehicle for technology access. As with FDI, reality does not often match policy, but nevertheless, as noted in Chapter 3, offsets have led to sustainable manufacturing and MRO capacity in some of the ASEAN4 countries. Offsets is an area not fully explored in the literature, particularly in the aviation field, and so further research is required. However, Chapter 3 has gathered evidence through empirical investigation that offsets can play a positive role in the technological development of the local aviation sector.

At a higher technological level, offsets have now replaced the 1930's technology diffusion process, whereby transfers move from Japan to the NICs and ASEAN4 countries (as per Akamatsu's Flying Geese Model). Instead of the diffusion of technology from the regional leader, Japan, the need for OEMs to provide offsetting investment to purchasers of 'big ticket' items has meant that technology now transfers directly from the US and Europe, by-passing Japan. In the process, offsets have created global production networks in aviation, spread across Asia-Pacific and further afield. Japan is itself part of these 'linked' networks, where manufacturing work is allocated according to the technological level of countries in the network. Thus, Malaysia and Indonesia receive work packages at a lower technology order than those agreed with Japan. Indeed, Japanese aviation company, Mitsubishi, is now a full technology partner with Boeing, each of these companies taking a 35% share in the production 'and' development of the B787 Dreamliner. For Japan, technology sharing is a ‘stepping-stone’ towards absorbing technology and ultimately achieving indigenous technological development. It is in this light that China’s search for self-reliance in commercial aircraft building should be seen.

Deng Xiaoping used two aphorisms in 1978 to explain and justify economic liberalisation as a means of promoting the development of China’s economy. The first had regard to China’s employment of Capitalism as a partial ideological rejection of Communism:

> 不管黑猫白猫,能捉老鼠就是好猫. Translation: It does not matter whether the cat is black or white; as long as it catches the mouse, it is a good cat. (Commenting on whether China should turn to Capitalism or remain strictly in adherence with the economic ideologies of Communism)

The second aphorism can be interpreted as explaining that the ‘stepping-stones’ for achieving a particular policy goal may not been visible at first sight, but are no less effective:

> 摸着石头过河. Translation: wading across a river by feeling the submerged rocks. (referring to the fact that China had absolutely no experience with modern Capitalism).

China’s ambitions to develop a sustainable and indigenous commercial aircraft industry have been delayed by war, militarism, communist inefficiency and, more recently, policy mismanagement (AVIC’s separation and then subsequent re-integration). However, in this third phase of foreign industrial cooperation there is a sense that at last a momentum has been achieved whereby critical mass, minimum scale, and a compelling commercial business case (for foreign OEMs) are factors finally propelling the aviation industry towards economic take-off. If this prognosis is correct, then Akamatsu’s Flying Geese Model requires fundamental amendment, as shown in Figure 6.1. The Figure offers a dynamic profile of China’s aviation industry, moving from Figure 6.1.a), the traditional Akamatsu view, where impoverished China does not even show-up in the Flying Geese Pattern, to Figure 6.1.b) where by 2020 China accelerates to a market position behind that of Japan, to finally, Figure 6.1.c), where by 2030, China has overtaken Japan as the aviation technology leader, becoming the ‘lead goose’.

6.2 Conclusions

In the 21st century, China is arguably the only country in the world that challenges the dominance of the global aviation duopoly, Boeing and Airbus. This is a global industry which demands big economies of scale to ensure viability. The fixed costs of R&D and production processes are huge, and when combined with the increasing costs of securing ever higher safety levels, environmental standards, and fuel- efficiency, then the risks of investment to achieve long-term sustainability are high. Scale is the factor that allows these rising cost structures and corporate/government risks to be managed and kept under control. However, scale is a relative factor, and the demand schedule that scale reflects will be influenced by numerous considerations, including the risks associated with the delivery of new products. In this regard, both Boeing and Airbus have suffered serious delays in the introduction into service of the B787 Dreamliner and the Airbus A380, respectively. The degree of competitiveness in the airline industry means that aircraft orders will be cancelled if aircraft cannot be delivered to schedule. Moreover, there is also the unpredictability of events that adds to the uncertainty of forecasting aircraft demand and thus scales of production. Strategic plans are built around assumptions of future market stability. But forecasting is a ‘black art’ and in reality nothing is stable, nothing is certain. The rapid and dramatic onset of the present international recession and the threat of global pandemics are evidence of this fact. It is thus due to these technical, financial and market risks that the aviation industry has transformed itself from the fragmented national market structure of the1920s/30s to the global duopoly reflecting today’s aviation industry. The sense of anticipation regarding China’s efforts to break the Boeing-Airbus aviation market stranglehold is because only China, over the next two decades, has the internal market potential of huge aircraft demand to deliver the production scale necessary for business sustainability. Align such demand and scale considerations with relatively high economic growth, rising income levels, an expanding consumer and corporate appetite for air travel, and most importantly, an ‘interventionist’ government that has the resources and commitment to

Figure 6.1: Dynamic Profile of Flying Geese Model Applied to the Aviation Industry, 2009-2030

Source: author

support the development of China's aviation industry, then, *ceteris paribus*, the chances are good for success.

Yet, how is success to be defined? Like scale, it is a relative concept, and for some companies it may simply mean survival, but for others, it will be market domination, either at the national or international level. In the international aviation market, there appears a pre-occupation with market share, characterised by the continuous public relations contests at the top end of the market, between Boeing and Airbus, and at the bottom end, between Embraer and Bombardier. New entrants to this market are rare, because of high barriers to entry. Thus, as around 90% of global aircraft production value is accounted for by Europe, North America and Brazil, China's efforts to develop a global aircraft industrial presence is remarkable, representing this dissertation's research problem. In addressing this 'problem', the study has attempted to evaluate the historical background to the industry's evolution. The impact of the liberalisation on the industry has also been examined to establish how the 'opening-up' of China and the encouragement of foreign aviation enterprise to participate in industrial development has progressed. In the process of evaluation, a number of questions have been addressed. Has technology transfer occurred? Has it been substantive and successful? Has it made a contribution to the development of a genuine 'Chinese' aviation industry? Finally, this study has sought to analyse the indigenisation of China's aviation industry by reference to certain metrics held to reflect the breadth and, significantly, depth, of local indigenous endeavour. Accordingly, based on the findings of the analysis in Chapter 5, this study offers the following conclusions:

Development: Taxiing along the Runway, Waiting for Take off …

1. China's aviation industry did not exist until 1950s:

The origins of China's aviation industry go back to the 1920s, when many of the industrialised countries were beginning to establish production capacity. It was WWI which advanced the development of aircraft and it was WWII which later consolidated and progressed the technological capability of the aviation industry. For

China, however, internal conflicts and the War of Independence against Japan caused the stagnation of aviation development. Chapter 5 identifies the modest beginnings of aircraft production in China, but also acknowledges that the country's only aircraft production pre-1950s was copy production of US warplanes (assembly of US aircraft kits produced in America) during the Second World War.

Development planning through Five-Year Plans was delayed until the mid-1950s due to China's active engagement in yet another conflict, the Korean War. Once China was able to focus its energies on development, then, finally, it was forced to confront the rigidities, inflexibility and contradictions of the Communist economic regime. Output was determined by production targets, not by market signals, such as price or profit. Efficiency and cost reduction did not factor into the equation. Equally damaging was the fact that the politico-economic environment was not conducive for risk-taking, technological innovation and market development.

The command economy has a role to play, particularly in the early development of an underdeveloped country. This will be through central direction of policy, careful allocation of scarce capital resources, identification and support of 'strategic' industries, and the adoption of a macro, long-term planning policy, based on the development of the economy rather than on a market forces perspective, driven by capitalist short-termism. In post-WWII China, development planning was centralised, but lacking in consistency and logic. In any case, for much of the post-war period the economy was in transition from agricultural dependence to industrial development and the thrust of planning was directed towards capital goods production and the associated build-up of defence capacity. This approach was in harmony with the Soviet Planning Model, and given the close Sino-Soviet partnership during the 1950s and early 1960s, China's aircraft production was almost totally concentrated on military aircraft; products and processes were sourced from the Soviet Union, and production was vertically integrated, as in the Soviet arms factories. This heavy policy focus on defence and combat aircraft meant that resources were not available for the sponsorship of commercial aircraft capacity. When Soviet collaboration ended, it quickly became clear that no indigenous capacity had been created. 'Production' had been through assembly of Soviet Aircraft and, as a consequence, no local design capacity and no supply base had been developed. In development economics, this absence of local capacity is often referred to as industrial ‘hollowing-out’.

From the 1960s through the 1970s, China attempted to develop local commercial aircraft capacity but the economy, whilst growing, was unstable, negatively impacted by macroeconomic planning uncertainties. The disastrous cultural revolution gave way to the ‘Hundred Flowers’ campaign, which in turn gave way to the Great Leap Forward. Mao Zedong’s death was the signal for political infighting, but change was about to come in the latter 1970s with Deng Xiaoping’s ‘open-door’ economic policies and implementation of the ‘Four Modernisations’: agriculture; industry; science and technology; and defence. Significantly, for aviation production, defence took the lowest priority amongst the Four Modernisations, encouraging, finally, an emphasis on commercial aircraft.

Technology Planning: the Focus on Post-1978 FDI

2. China’s reliance on FDI for access to technology was necessary, but not sufficient.

China’s embrace with capitalism was delayed and not total, but it was certainly welcome, and in ‘harmony’ with the process of liberalisation that would accelerate over the coming decades. China, as evidenced, through policy statements, would welcome foreign technology and expertise to support the development of local industry and this transfer of technology would complement centralised government policies to promote ‘strategic’ industries. Import-substitution industrial strategy would be conducted under market-socialism principles. An ideological and theoretical contradiction, perhaps, but in light of the recent revealed excesses in capitalism, it is a hybrid planning model that clearly carries merit.

Even after the 1989 Tiananmen Square incident, foreign investment was attracted to China, but not in great volume until the mid-1990s, when globalisation and the charisma of Deng Xiaoping persuaded foreign enterprise that China’s economy was on a long-term trend of rapid growth. Agreements would be honoured, foreign investments would be safe, and importantly, money could be made.

However China's ambitions of gaining technology through foreign partnership did not materialise. This study's field work confirms that minimal technology was transferred. This is, perhaps, unsurprising given the foreign OEM's obvious reluctance to release technology: if they were to do so, they would quickly lose their comparative and competitive advantage. There is some evidence from foreign aviation suppliers, such as Rolls-Royce, operating in China, that to secure long-term sovereignty, Beijing prioritizes competitiveness, over access to technology, to achieve sustainability, at least during the 1990s to the present time. In assessing the contribution of FDI to the development of Chinas' aviation industry, it is certainly the case that global players, such as Airbus, Boeing, Embraer, Rolls-Royce and Safran, have contributed to the development of local capacity in the production of components and sub-assemblies, but this falls short of laying a strong local design and manufacturing base for indigenous industrialisation. In this regard, the foreign OEMs have been necessary but not sufficient. What is also required is indigenous capacity and this can only come about through greater self-reliance, arguably through design and production of 'Chinese-made' commercial aircraft.

Technology Development: Encountering Turbulence from China's Early JV Aircraft Programmes

3. China's early aircraft construction programmes were a failure:

Several decades of attempting to design and produce 'Chinese' commercial aircraft have led to failure, when defined as the creation of a viable, sustainable, aviation industry. Examples of failure litter the development of the industry. In the 1970s, China successfully developed from a Soviet design, the Y-10 commercial aircraft. This was a significant first step, though one which did not lead to follow-on models, and eventually had to be abandoned. Also, the collaborative venture to license produce the MD-82, along with plans for its successor model, the MD-90, also ended in the termination of the programme, due to a variety of reasons, including Boeing's acquisition of McDonnell Douglas, and non-procurement of the MD-90 by China's airline companies, which had evolved to become commercial entities in the newly liberalised Chinese 'market' economy. There was, finally, China's attempt in the 1990s to engage in the development of a medium-sized passenger aircraft through an international collaborative programme. The project was called the *Asian Express 100*, but this also eventually foundered over the failure of the principal partner, China, to obtain substantial technology transfer. Into the 21st Century, then, the development of China's aviation industry can be characterised as four decades of policy effort resulting in the failure to both design and manufacture a 'sustainable' Chinese commercial aircraft. However, the planning question linked to this study's research problem, is to what extent has FDI, combined with local investment, created an industrial and technological platform for future growth and development of China's aviation industry?

Indigenous Industrialisation: the Elusive Goal?

4. There is little evidence to support the view that China has created an 'indigenous' aviation industry:

It is clear that the 'open-door' policies of Deng Xiaoping alongside the impressive growth on the demand-side of China's aircraft market have encouraged foreign aviation companies to relocate capacity into China. It is on the supply-side, however where the weaknesses lie. The following grouping of conclusions from this study's fieldwork represents an objective evaluation of the impact of government policies to date:

4(a). **Government policy has been directed, supportive, and coordinated:**

On the plus side, government policy has been a powerful force in implementing positive change in the aviation industry. Whilst mistakes have clearly happened, such as the separation of AVIC I and II and then nine years later their re-integration, the government's strategic approach has led to substantial strengthening of industrial activities. Importantly, the encouragement of foreign OEMs has created new skills, capacity and learning. There remain questions as to the 'depth' of the capabilities created, but the beginnings of an industrial aviation landscape have been put in place.

4(b). **Policy has actively promoted both industrial and technological clusters and global production networks:**

Fieldwork investigation indicates that progress has been made in integrating Chinese production of components and subassemblies into the foreign OEM global supply chains. Thus, not only have foreign aircraft companies awarded subcontracts to Chinese aviation enterprises, but this output has been networked into the global production chains of both Boeing and Airbus. Much of this output was originally linked via technology offsets to China's purchase of foreign aircraft. From a policy perspective, it is critical to see whether China will win future contracts on a competitive basis or whether offsets will remain the lever. It is important to recall that while composites contracts awarded to Malaysia and Indonesia were the result of open competition, the original deals which created the capacity and learning were offsets-driven. In addition to China's participation in global production networks through the government's FDI policies, central planning has also led to the promotion of strong aviation industrial clusters. The central and municipal authorities have invested heavily over the last decade in creating aerospace clusters of local and foreign OEM and supplier companies in cities, such as Shanghai, Tianjin, Harbin and Chengdu. Cluster formation is a 'hot' topic in the West, where governments are actively promoting clusters for the purpose of stimulating product innovation and production efficiencies, particularly directed towards high technology industries, including aviation. Significantly, aviation universities are being linked into China's clusters.

4(c). **The creation of local supply chains has made only modest progress at this point in time:**

Fieldwork results indicate that Chinese high tech. value chains have not emerged. Local expertise and capacity were not in place when FDI first started to penetrate China's aviation industry in the 1990s, but with the support of foreign OEMs to ensure acceptable quality, and, arguably, increasing pressure from the Chinese aviation authorities, gradual, though not dramatic, progress is being made. What appears to be happening at present is that foreign OEMs located in China are procuring from their regular (foreign) suppliers, now also relocated to China. This adds to local employment, but not to 'deep' technological capability if the high technology packages are imported and simply assembled in China.

4(d). **Technology innovation in China is characterised more by the provision of training than research and development:**

The responses from interviews and questionnaires indicate that although aviation companies are actively sponsoring training and education, which will be beneficial for the future development of the industry, there is little evidence to suggest that original R&D is occurring. Thus patents are limited, and, outside of AVIC, corporate R&D institutes do not exist. Value-added in China's aviation industry remains low, and this is because only meagre indigenous production exists. Fieldwork findings show that indigenous content is low for all producers of commercial aircraft in China. Whilst 97% of Embraer's ERJ-145 aircraft is assembled in Harbin, only a small amount of subcontracting is undertaken in China. Moreover, at the present time, Boeing does not produce complete aircraft systems in the country, probably due to US-China politics inhibiting post-Tiananmen US technology transfer. Airbus has agreed to local assembly of its Airbus A320 aircraft, but there is to be no 'real' technology transfer, and local production rather than 'assembly' will be incidental and *ad hoc*. Similarly, with Roll-Royce and Safran, with neither company agreeing to anything but modest technology transfer. Indeed, even the 'Chinese' ARJ-21 is not an indigenous aircraft, with at least 80% of the systems and sub-systems supplied from foreign OEMs; and irrespective of whether they are, or are not, located in China, local value-added remains severely limited.

China's Indigenous Aviation Industry: Blue Skies Ahead?

5. A more speculative conclusion, albeit based on interview data, is that within two decades, China will have an indigenous aviation industry to compete with Boeing and Airbus:

Whilst the conclusions from this research do not provide an enthusiastic endorsement of the progress China has achieved in developing an indigenous and sustainable aviation industry, there is a sense that a critical mass of demand and supply capacity, has now been reached. The huge market potential for commercial aircraft to service Chinese air transportation growth will incentivize foreign OEMs to increasingly partner, and even share, and jointly develop aviation systems with their Chinese counterparts. Significantly, the Chinese government will play an important strategic role in directing future technology development. After decades of failure and disappointment, the authorities remain committed to the goal of developing their own commercial aircraft industry. The ARJ-21 is just a ‘stepping-stone’ for achieving the main ambition of developing and producing a Chinese ‘large’ wide-bodied commercial aircraft. Planning for this is now advanced, as is the new RMB6bn investment in a big aerospace engine facility to develop the engine that will power this large passenger aircraft.

6.3 Policy Recommendations

This study has not been concerned with business analysis, though clearly micro-performance impacts on macro development. Policy recommendations will thus be at the strategic level, reflecting on how technology development and indigenous industrialisation can be achieved. This suggests policy relevance to both the Chinese government and foreign OEMs wishing to share in the benefits of the rapid growth and development of China’s aviation industry. It goes without saying that these policy recommendations, directed at China, will also resonate with the circumstances of Asia’s wider emerging aviation industry.

The policy recommendations, as derived from the principal conclusions (section 6.2), of this study, are as follows:

1. **Government has played, and will continue to play, a critical role in sponsoring the development of China’s aviation industry.** To date, the results of this sponsorship have been mixed. However, many of the aviation experts and executives (Chinese and foreign) interviewed during the fieldwork expressed the view that within two decades China will have developed a powerful local aviation sector, built around the domestic aviation giant, AVIC. This opportunity (or threat – if you are a competitor company) needs to be recognized by policymakers at the corporate and governmental level and appropriate coping strategies thought through.

2. **It is recommended that industrial planners in China undertake comparative evaluation of the policies and progress achieved in the specialist aerospace clusters that have been promoted, especially in France and Japan.** China has made a strong start in creating high technology aviation and aerospace

parks and clusters, but more needs to be done in integrating aircraft companies into such clusters, particularly via the creation of local supply chains.

3. **An important attribute of 21st century cluster development is the need to ensure that foreign enterprises are encouraged to integrate within the cluster, benefitting all stakeholders from their industrial participation**. China's planning authorities need to evolve policies to accelerate foreign OEM involvement in the emerging aviation clusters, facilitating knowledge dissemination, innovation through horizontal and vertical technology pressures in the value chain, and joint R&D via tie-ups with cluster-based specialist universities.

4. **In terms of technology access, it is recommended that China undertake comparative empirical evaluation as to the success of technology offsets in creating the industrial foundation of local capacity and skills. Particular attention should be paid to securing sustainable production of aviation components and sub-assemblies awarded under competitive contracts.** Offsets as a facilitator of indigenous technology development is an important finding from this study's Asia aviation fieldwork, because it contradicts the conventional view that benefits from offsets are illusory.

5. **China's policymakers are recommended to examine the successful ST Aerospace strategic model based on an MRO focus within the commercial sector.** ST aerospace's preparedness to exploit the synergies that exist between its civil and military is instructive. This is significant to China, given that the re-integration of AVIC is aimed at separating civil and military aircraft building operations, driven by political requirements over US aviation industry participation in China's future aircraft projects.

6. **It is recommended that China pursues an interim strategy of promoting skills for integration of the systems and sub-systems of passenger aircraft in defined market niches.** This is essentially the Embraer Model, but whilst Brazil does not offer local market volume or the resources for long-term expansion of value added through indigenization of foreign OEM systems, this is not the case with China. China

has already started to travel along this strategic path with the ARJ-21 project, but it can be taken further.

7. **This doctoral-level research project has signalled to the broader Chinese aviation community that beyond the 'fascade' of shiny new aircraft models produced in China, including those supposedly 'Chinese', there is remarkably little value that is being generated from within the Chinese aviation industry**. This is a high cost form of development, given that 'off-the-shelf' acquisition of foreign passenger aircraft will certainly carry a lower cost. It is therefore recommended that a debate be started amongst informed stakeholders, Chinese and foreign, to consider the purpose and nature of developing China's aviation industry. This doctoral study will hopefully initiate the beginnings of such a debate, and the intent is that others will make their own contribution to this important debate.

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Appendix 1

Asia's Commercial Aerospace Industry Questionnaire

Questionnaire Aim: To evaluate Asia's Aerospace industrial performance. The information gained from the completion of the questionnaire will provide the contextual and comparative background to a more focused study examining the development of China's aerospace industry; the latter being one of its emerging hi-tech pillar industries.

Guidance in completing the questionnaire: most of the questions are UNSTRUCTURED, allowing survey participants to comment broadly and deeply on particular issues. All replies will be treated as confidential.

Sections covered in this survey:

A General Information
B Foreign Direct Investment
C Cross-Cultural Challenges
D Government Policy
E Indigenous Technology Development

Data Sensitivity: The questions are mostly descriptive and non-sensitive. The survey data are intended to support a Chinese student's doctoral research.

Output: It is planned that the work will be published and a copy of the article will be distributed to all survey participants and other interested observers. This will allow the study results to be disseminated more widely, encouraging others to make their own contribution to this important debate.

A. General Information

1). Respondent name/designation:____

2). Company name:____

3). Year of establishment:____

4). Company ownership:____

5). Range of products/services produced:__________________________________

6). Employment when company started:_____________________________________

7). Employment in 2008:____

8). Number of production facilities:____

B. Foreign Direct Investment

9). What are your sources of technology transfer?

- ☐ Technology acquisition
- ☐ Joint venture
- ☐ Use of technical publications
- ☐ Foreign Direct Investment
- ☐ Purchase of corporations
- ☐ Sale of technology data
- ☐ Technical personnel
- ☐ Offset programmes
- ☐ Total project contracting
- ☐ Total process contracting
- ☐ Major process contracting
- ☐ Know-how contracts
- ☐ Trademark agreements
- ☐ Franchise agreement
- ☐ Engineering services contracts
- ☐ Employment of experts
- ☐ Technical consultancy contracts
- ☐ Licensing
- ☐ Purchasing machinery supplies
- ☐ Use of personal contacts
- ☐ Others, (Please indicate strategy): ________________________________

10). Number of FDI projects, by country:

	0	1	2	3	4	5	Above 5
US							
Japan							
Taiwan							

Korea							
Dutch							
Germany							
France							
Other (please specify							

11). Do you believe FDI has been successful?

Yes ☐ No ☐

If the answer to Q11 is yes, State what you believe have been the critical success factors?

____

____

____

12). What have been the biggest challenges? (rank in order of importance)

- Access to technology ☐
- Insufficient finance ☐
- Acceptable level of communications with foreign partner ☐
- Achievement of acceptable product quality ☐
- Appropriate local skills ☐
- Efforts to indigenise production ☐
- Lack of awareness: many organizations are not aware of available technology. ☐
- Lack of knowledge: if an organization is short of skills and knowledge, it may be unable to use the technology offered. ☐
- Lack of funds: organizations may be unable to purchase or develop technology. ☐

- Lack of common interest: organizations may exhibit a lack of motivation to reach agreement or settle differences of opinions about available options. ☐
- Conflict of interest: competing organizations may be unwilling to collaborate. ☐
- Poor coordination: individuals within an organization or collaborating organizations fail to effectively coordinate about activities, processes, goals and directions of the venture. ☐
- Lack of resources: this can include both physical resources and loss of a key member. ☐
- Lack of time. ☐
- Lack of trust. ☐
- Technical problems ☐
- Changes in the project structure ☐
- Organizational problems ☐
- Management attitudes ☐
- R&D effectiveness ☐
- Short-term pressure ☐
- Resistance to change ☐
- Poor information flow ☐
- Weak links between customers and suppliers ☐
- Dependency on public R&D institutions ☐
- Cultural differences ☐
- Geographic differences ☐
- Others (please specify)

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13). Has FDI improved the growth and development of your company?

Yes ☐ No ☐

If the answer to Q13 is yes, please specify in what ways has FDI has contributed to the growth/development of your company?

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____

C. Cross-Cultural Challenges

14). Has your company experienced cross-cultural problems with its overseas partnerships?

Yes ☐ No ☐

15). Please provide examples:

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16). How were these problems resolved?

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D. Government Policy

17). In what general ways has government policy supported the growth and development of your company?

____

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18). What existing policies need to be improved? What new policies need to be put in place?

Yes ☐ No ☐

19). Has government policy assisted with R&D?

Yes ☐ No ☐

20). Please give details:

21). Is stronger government support required?

Yes ☐ No ☐

If the answer to Q21 is yes, state in what ways government can help?

22). Has government policy assisted the process of FDI with your company?

Yes ☐ No ☐

23). Please give details:

E. Technology

24). Please estimate the level of value-added in your company's principal product fields:

Product	1-9%	10-19%	20-29%	30-39%	40-49%	50-59%	60-69%	70-79%	80-89%	90-100%

25). Is FDI located only at the production level?

Yes ☐ No ☐

26). Has FDI begun to move upwards into higher value added activities like R&D?

Yes ☐ No ☐

Please give details:

____

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27). Number of local patents registered, if any? ____________________

Yes ☐ No ☐

28). Has FDI raised local work skills?

Yes ☐ No ☐

Please give details:

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29). Has FDI actively encouraged the development of local subcontractor networks?

Yes ☐ No ☐

30). Please explain how FDI has helped the development of local suppliers:

31). Have industrial networks/clusters assisted in the development of your company?

Yes ☐ No ☐

If the answer to Q31 is yes, explain in what ways networks/clusters have helped?

32). In your view, what can be done to expand and develop indigenous supply chains?

33). Does your company cooperate with science parks? Please provide details:

Appendix 2
附录二

China's Aerospace Industry Questionnaire
中国航空工业调查提纲

Questionnaire Aim: To evaluate China's aerospace industrial performance. The information gained from the completion of the questionnaire will provide data for evaluating the development of China's aviation industry; an emerging and hi-tech strategic industry. All replies will be treated as confidential.
目的：本调查所搜集的资料，将为中国新兴的高新技术产业发展现状研究，特别是航空工业研究提供相关背景。

F. Foreign Direct Investment关于外国直接投资

1). Do you believe that FDI .foreign collaboration in aerospace has been successful? 您认为外国直接投资进入中国成功吗？

Yes 是 ☐ No 否 ☐

If your answer to Q12 is yes, please specify the major critical success factors. 如果您的答案是肯定的，请说明原因。

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____

2). What have been the biggest challenges?外国直接投资的最大挑战是什么？

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____
____
____

3). In your view, have FDI processes improved the growth and development of China aerospace?

Yes 是 ☐ No 否 ☐

If the answer to Q14 is yes, please specify the nature of such processes. 如果您的答案是肯定的，请说明原因。

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G. Cross-Cultural Challenges 关于文化差异

4). Has the aerospace industry experienced cross-cultural problems with its overseas partnerships? 外国直接投资是否面对跨国文化差异问题?

Yes 是 ☐ No 否 ☐

Please provide examples: 请举例说明与合作伙伴的文化差异。

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5). How were these problems resolved? 如何解决以上问题?

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H. Government Policy 关开政府政策

6). In what ways has government policy supported the growth and development of aerospace capacity? 政府出台哪些政策支持航空工业发展?

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7). Has Plan 863 or other government policies been important supportive policy instruments? 863计划是扶持政策的一部分吗？

Yes 是 ☐ No 否 ☐

Please provide examples: 如果是请说明具体内容。

8). What existing government polices need to be improved? What new policies need to be put in place? 政府现有哪些政策需要改进，哪些政策需要进一步加强执行?

9). Has government policy assisted with R&D?

Yes 是 ☐ No 否 ☐

Please give details:

I. **Value-added Performance**关于 增值表现

10). Please estimate value-added in your company's principal product fields. 请评估航空工业公司主要产品的增值部分？

Product	1-9 %	10-19 %	20-29 %	30-39 %	40-49 %	50-59 %	60-69 %	70-79 %	80-89 %	90-100 %

11). Do local content regulations exist? 本地的政策包含什么内容？

Yes 是 ☐ No 否 ☐

12). Explain how FDI has helped to indigenise production in your business?外国直接投资有助于企业的国产化吗？如果“是”的话，又是如何实现国产化的？

13). Has FDI begun to move upwards from production into higher value added activities like R&D? 外国直接投资是否从制造生产转移到高附加值的研发？

Yes 是 ☐ No 否 ☐

14). Is it policy to develop local supply chains? 企业发展策略是否促进当地供应链的发展

15). Provide examples of development cooperation between aerospace prime contractors and local suppliers: 贵公司如何与当地供应商发展合作？

16). What % of total supply is sourced locally for selected airliners? 贵公司本地供应商的数目？

___

17). Explain the intentions/plans to raise value-added in the future: 请您简要介绍公司计划，如何增加产品的附加值？

J. Technological Innovation技术创新

18). What are your sources of technology transfer? 贵公司主要技术来源何处？

19). Are there commercial aerospace R&D facilities in China?

Yes 是 ☐ No 否 ☐

20). Explain the principal activities of such R&D plants? 贵公司有研发机构吗？.

__ Yes 是 ☐ No 否 ☐

21). Estimate the total number of commercial aerospace R&D staff in China贵公司研发员工人数？

22). Estimate the % of R&D staff possessing PhDs: 其中多少员工拥有硕士、博士学位？有多少是本土人才？

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23). Are there any aerospace patents held in China贵公司持有中国专利数目(请具体说明)

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24). Has your company tried to encourage an innovational culture?

Yes 是 ☐ No 否 ☐

25). Explain the principal aspects of this innovational policy/culture: 请介绍企业的创新文化。

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26). Has government policy supported China's aerospace technological development? 政府有否出台支持贵公司技术开发与技术创新的政策？

Yes 是 ☐ No 否 ☐

Please give details: 请举例。

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27). Can you explain the nature China’s aerospace cooperative agreements with local R&D institutes and/or universities? 贵公司有没有与本地研发机构和大学合作?

Yes 是 ☐ No 否 ☐

Please give details: 请举例。

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K. Skill Generation 技术水准

28). Comment on China’s approach to aerospace training/education 对中国航空工业人才培训的看法?

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